London Metropolitan University

Masters in Architecture, Energy and Sustainability
European Masters in the Integration of Renewable Energies into Buildings

Module AR52P

ESP-r

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Table of Contents

.....2
1 STRUCTURE OF THE COURSE..... 3
2 INTRODUCTION.....4
3 STRUCTURE OF THE PROGRAM.....4
4 GETTING STARTED..... 6
5 MODEL GEOMETRY.....9
5.1 Add a window to a surface..... 12
6 CONSTRUCTIONS.....15
7 OPERATION..... 17
8 SIMULATION integrated run.....21
9 RESULT ANALYSIS graphs..... 22
10 DATABASE MODIFICATIONS..... 22
11 A SIMPLE HEATING/COOLING CONTROL.....24
12 SIMULATION interactive run..... 27
13 RESULTS text mode.....28
14 AIR FLOW NETWORK..... 28
14.1. Natural Ventilated Zone - Control for air flow network by opening the windows....36
15 RESULTS.....39
15.1 Text description..... 39
15.2 Graphs..... 39
16 Bibliography..... 42
ANNEX 1 Materials database..... 43
ANNEX 2 Constructions database.....46
ANNEX 3 Configuration file.....53
ANNEX 4 Results - Hours above a certain value..... 56
ANNEX 5 Results - Energy Consumption.....57
ANNEX 6 Results - Wind data..... 59
ANNEX 7 Control file.....60

1 STRUCTURE OF THE COURSE

1st Day

Objectives: become familiar with the *Project Manager* and create the mandatory files to perform a simulation.

The following tasks will be carried out:

- Geometrical definition of two zones (a 2 storey flat);
- Definition (selection of defaults) of constructions for the surfaces defined;
- Connection of the surfaces if in contact to a zone other than the exterior;
- Creation of a window within a wall and attribution of transparent material;
- Creation of internal gains as occupants and/or lighting and equipment including operation schedules;
- Creation of an infiltration and/or ventilation system (user defined air changes) and its operation schedules;
- Use of the simulator module;
- Use of the results analysis module.

2nd day

Objectives: development of skills by testing optional modules.

The tasks to be carried out:

- Creation of a multi-layer construction to be used instead of the default;
- Creation of a simple heating and/or cooling system.
- Result analysis of energy demand.

3rd day

objectives: study of an air flow network on a naturally ventilated model.

The tasks to be carried out:

- Definition of nodes, components and connections of the flow network;
- Definition of a control for the air flow simulating the opening of the windows;
- Generation, analysis and storage of results.

2 INTRODUCTION

ESP-r is a transient energy simulation program that allows modelling the energy and fluid flows within a combined building and plant system. Since it is one of the most powerful dynamic thermal simulation tools, its operation is non-trivial. However ESP-r is one of the best validated packages of its kind, so the results very accurately reflect the real building environment, provided the input is well defined.

The aim of this 3 days course is to provide you with a basic knowledge of the ESP-r software to perform a building energy analysis. In order to use the software professionally, further studies will be necessary.

Before attempting to start working with the program you need to define your objectives and criteria, as well as the expected results.

There are several rules that should be followed:

- Spend some time and think what you are trying to do before initiating with the software;
- Plan in advance what you expect to achieve and what is the best model or tool to reach your aims;
- Try to simplify the input of the project. This means a careful choice should be made to the definition of the model. The more complex the input the likelihood the chances of errors for beginners and time consuming that with probably add no significant changes in the results;
- Test first on a small scale before aiming at bigger or complex situations. Sometimes a simple analysis might prevent time spending on a solution that does not obtain significant results;
- Assign plenty of time to analyse the results and draw your conclusions.

3 STRUCTURE OF THE PROGRAM

ESP-r can be divided into three distinctive parts. The first one is concerned with the establishment of a valid data model (description of the building and/or plant configuration) for the simulation. The second part is related to the simulation processing. The third one with the results recovery and analysis. All the parts are accessed via a `Project Manager`. This interface also provides access to other program software and support applications such as RADIANCE modules, tutorials, databases or export facilities of the results.

ESP-r is structured in different modules. As soon as you start the program the software will create an unique folder or a a set of folders and descriptive files to be accessed later in the program. Table 1 shows the default structure for a fictitious project 'duplex'.

Table 1 Folders structure

folders	***type***
duplex	project folder
duplex/**cfg**	system files
duplex/**ctl**	control files
duplex/**zones**	zone files
duplex/**nets**	networks
duplex/**doc**	reports and notes
duplex/**temp**	odds+ends
duplex/**dbs**	project databases

ESP-r will also apply different file types with extensions and redirect them to the defined folders. See Table 2.

Table 2 Filename convention

File type	***Extension***
System Configuration	.cfg
System control	.ctl
Geometry	.geo
Construction	.con
Operations	.opr
Shading/Insolation	.shd
View factors	.vwf
Air flows	.air
Convention Coefficients	.hcf
Site obstructions	.obs
Mass Flow Network	.mfn
Transparent Constructions	.tmc .con
Casual Gains Control	.cgc

ESP-r also includes databases which are essential for the simulation (primitive and composite constructions, event profiles, plant components and climatic collections). Depending on the installation they are usually on the following directories and folders:

*prm /usr/esru/esp-r/databases/constr.db1

*mlc /usr/esru/esp-r/databases/multicon.db1

*opt /usr/esru/esp-r/databases/optics.db1

*prs /usr/esru/esp-r/databases/pressc.db1

*evn /usr/esru/esp-r/databases/profiles.db1

*clm /usr/esru/esp-r/climate/clm67

*pdb /usr/esru/esp-r/databases/plantc.db1

These databases can be accessed and viewed through the `Project Manager` but depending on the users permissions, they can be modified if copied to a different directory. A good example of use of these databases are the primitives (materials) and multiconstruction (layered construction) databases that can be accessed to select typical materials and construction systems for the building envelope.

To perform a simulation with ESP-r, the following file types may be produced:

- A mandatory ***geometry***, ***construction***, and ***operation*** file for each zone;
- A mandatory ***system configuration*** file and an optional ***configuration control*** file;
- An optional ***air flow***, ***casual gains***, ***shading/insulation***, ***view factors***, ***surface convection*** and ***transparent multi-layered construction*** file for some or all zones;
- An optional ***fluid flow network*** description file, a ***pressure coefficients*** file;
- ***Fluid flow results*** and ***simulation results*** files.

1 NOTES

All data in ESP-r are expressed in *SI* units.

- The question mark sign **`'?'`** provides a tutorial (help) on the options asked. The letter **`'d'`** presents the defaults values;
- There is no **undo** button.

4 GETTING STARTED

Log on a computer and type

`esp-r`

on the command line. This will start ESP-r in its default graphic mode. See Fig. 1.

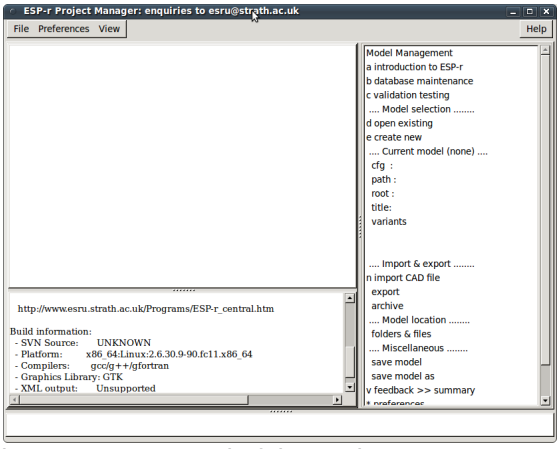


Figure 1: Entry Level of the Project Manager

If you are starting a new file, at the `Project management` select the menu option e `create new`.

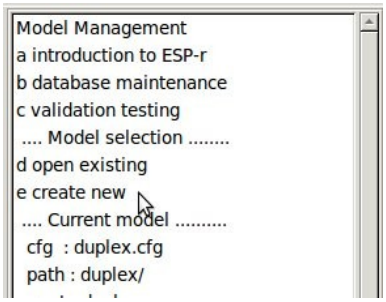


Figure 2: Menu create a new project

You will be asked to define a name (ex. ***ac***) followed by a choice of a single or standard set of folders where the descriptive and results files will be forward to. See fig. 3. As your model is relatively simple you can select a single directory. For a multiple structure please refer to table 1.

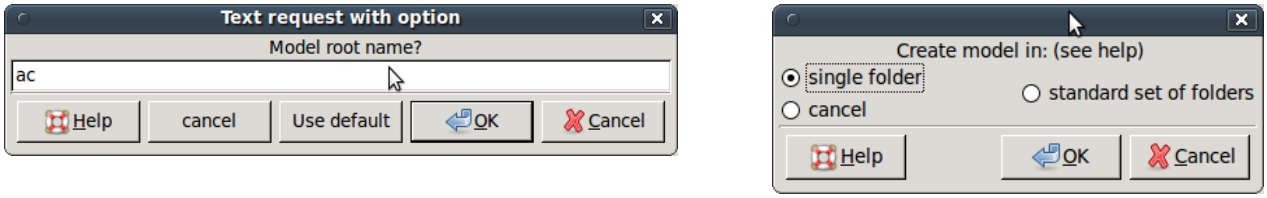


Figure 3: Windows defining root name and directory structure (single folder)

As default, the root name will be used for the following files created with the appropriated extension. Do provide a simple description of the project to remember on a later occasion, see fig. 4

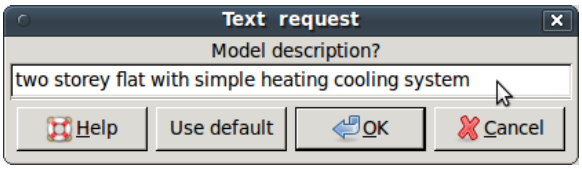


Figure 4: model description

A file called ***ac.log*** will be created, you may want to use it as your “note book”. Other questions will be asked, see fig. 5, as well as general parameters related to the building as site latitude (degrees positive north of equator) and longitude difference (degrees positive east of the time meridian of the place).

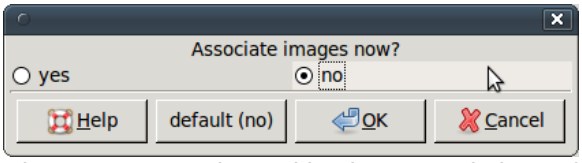


Figure 5: Question with the association of images

Examples of longitude difference are -4.1 for Glasgow relative to Greenwich and +2 for NY relative to 75° standard meridian without daylight savings. However, they can be changed

later as well parameters such as ground reflectance and site exposure. See Model Management > m browse/edit/simulate > b model context in Fig. 6.

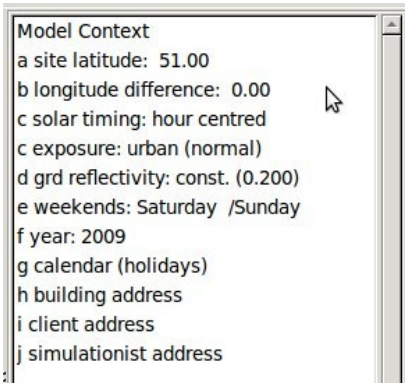


Figure 6: Model context menu

By this step the program has already created the folder structure and at least the configuration file. Exit the Model management by selecting -exit Project manager. You will be asked to save your data before you exit if you haven't done so before. When you launch the model again you can select the model you are working with its ac.cfg file. On the command line change to the directory created by the software and subdirectory cfg as:

cd ac (single directory) or **cd ac/cfg** (structured) .

Now relaunch the software with the indication of the system configuration file as:

esp-r -file ac.cfg

For a memory stick mounted at **/mnt/sda1** for a "ac" project with a configuration file named "ac.cfg" do:

cd /mnt/sda1/ac

esp-r -file ac.cfg

In the initial Model management (see fig. 1) select the menu option m browse/edit/simulate to carry on with setting up the model.

The following frame Browse/Edit/Simulate will be the main access point to the selection of the menus such as zones (model geometry and constructions definition), networks and controls. It will also be the interface for actions such as the simulation run and the result analysis.

5 MODEL GEOMETRY (mandatory)

NOTES

- Try to reduce the number of zones to a minimum. Avoid detailed definitions;
- The coordinate system X Y Z refers to the east, north and up directions respectively;
- It is easier to create the geometry of the zones on a regular grid orientated to the axis. Later individual zones or the whole model can be rotated and transformed to the real position;
- The position of the zones in regards to the origin have no importance if no shading analysis is to be made because the program recognises the interconnections between the spaces irrespective to its origin positioning. This means that all the zones can be located at origin as long as they are well orientated.
- In order to facilitate future recognition of a specific zone try to be consistent in the names attributed to the zones, e.g. zones on the 1st floor could be named z11, z12, ... on the second floor z21, z22 and so one. Names should be maximum 12 characters long and without spaces and commas.

The next step should be to create the geometry of the zones defining the model. See Fig. 7.

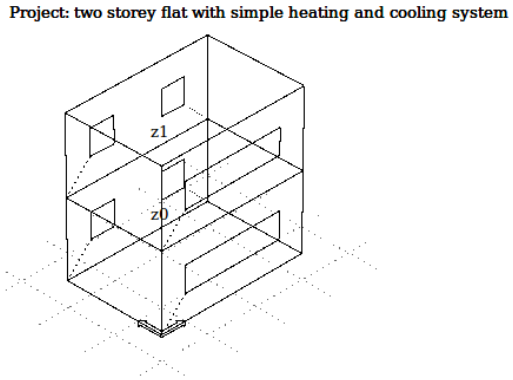


Figure 7: Model frame of geometry

Select Model Management> m browse/ edit/ simulate >> Browse/Edit/Simulate> c composition>> Zones Composition> a geometry and attribution

>> ***Zone*** **geo**metry and attrib

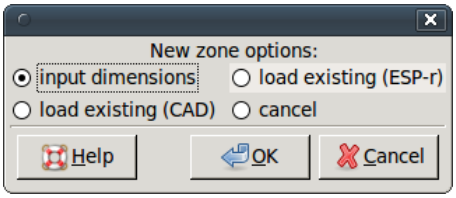


Figure 8: new zone input options

After defining a name (maximum 12 characters without blanks) and a short description of the zone (64 characters), you may create the geometry with input dimensions, load existing Esp-r or CAD. as in figure 8, and a base geometry as in fig. 9.

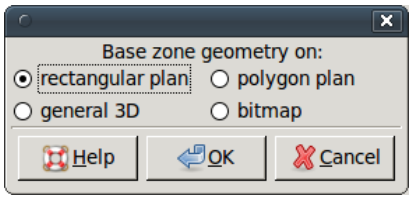


Figure 9: zone geometry options

HELP

You have the option to describe zone geometry as an extruded rectangle, a floor plan extrusion or a general polyhedra. Keeping the geometry as simple as possible will simplify the constructional attribution and result interpretation tasks.

Points from a bitmap:

Zone geometry can be defined by taking points from a scanned image of a site plan or floor plan.

To do this you need to scan the relevant source and then convert it to an XBM (X11 monochrome bitmap) file, which should be placed in the project `cfg` folder.

Please ensure that the bitmap is large enough to allow for accurate positioning of the mouse. The bitmap can be larger than the graphic display area, and where it is you can pan left/right and up/down.

The source image should have indications on it of an origin (typically X=0.0 Y=0.0), the North direction and a line of known length (to get scaling from).

Four options are then presented after the selection of the input dimension :

- rectangular plan – define the coordinates of the origin; the prism width, depth and height. Assuming the prism is orthogonal to the coordinated system width, depth and height are the length of the vector in the X, Y and Z axis respectively. The orientation of the prism may be corrected by the rotation angle measure in degrees anticlockwise from the X axis, see fig. 10.
- polygon plan – define the elevation of the base, the elevation of the top and number of walls (excluding the base and top). The coordinates of the base vertex are defined in the X and Y axis (input the coordinates around the base polygon anti-clockwise looking from the top, preferably beginning from the lower left corner of the enclosure). The extrusion rotation is the angle between the site Y-axis and north for the prism assuming anticlockwise as a positive rotation. Note this is different from the box orientation associated with the extruded rectangle.
- General 3D – define a set of vertices and then link them together to form surfaces (linked anticlockwise from the lower left when viewing the outside of the surface). You will be prompted for an origin point and a 2m x 2m floor surface will be placed there.

From this initial surface, modify the existing vertices to create the zone enclosure;

- bitmap – define the points of the zone by clicking on a image. The plan of the model should have been scanned and saved in a XBM file format and kept on the `cfg` folder of the project.

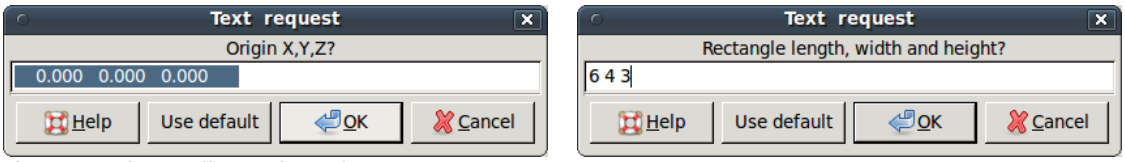


Figure 10: input dimension of zone

After creating your first zone the wireframe similar to the one in fig. 11 should appear on the screen.

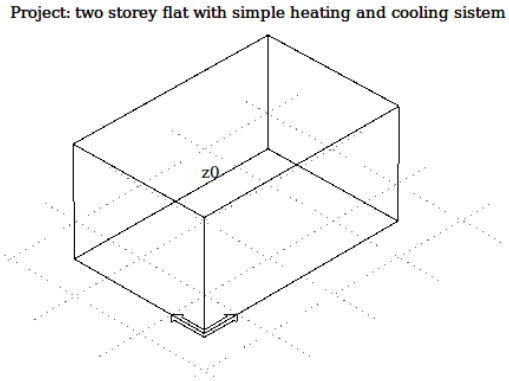


Figure 11: zone z0 wireframe

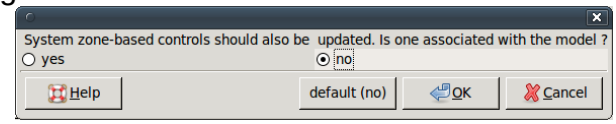
Although the program saves the definitions created it is a good approach to save the model regularly. In this menu save by selecting `Zone '1' Geometry> > save`

To create the second zone select - *`exit this menu`* to return to the menu one level above `Zone Geometry/Attribution` *and `* add/delete/copy.`*

If you decide to `add` a new zone follow the procedure previous explained.

If you decide to copy and existing zone after giving a new name you will be asked to transform and/or rotate the new zone. You may want to wait a little until the model includes further details, such as windows or composition of surfaces, before copying it.

If you decide to delete a zone select the zone in question and answer the questions listed fig. 12.



As at this point no controls have been defined yet.

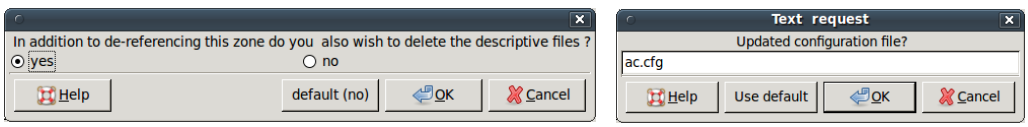


Figure 12: delete zone links and update configuration file

As you might have noticed the program creates default surface names for the zone enclosure. The rule is the first vertical surface anticlockwise from origin is Wall-1. Wall-2, 3 and 4 are the following walls in a anticlockwise direction. The top horizontal plane is Top-5 and the ground floor Base-6. To change these to names which are more easily recognised go under Model Management> m browse/edit/simulate>> Browse/Edit/Simulate > c composition>> Zones Composition> a geometry & attribution>> Zone Geometry/Attribution and select a zone. In the menu Zone '1' Geometry select *f surface attributes* >> Surfaces in z0> a Wall-1. Under the menu Surface Attributes > a surface name change the name (e.g. z0_ext_s as surface in zone z0, being exterior and facing south). Do the same for the remaining surfaces. See fig. 13.

In this menu you may also define the construction of this surface by selecting ***e construction*** which takes you to the **Composite** menu of the database, and ***f environment*** which takes to the ***surface boundary*** of the surface.

In the menu Surfaces in z0 you may * attribute many surface attributions, namely composition and boundary condition. For more details on these attributes see section 6. Don't forget to save under Zone 1 Geometry > *save* to update the '*.geo' file.

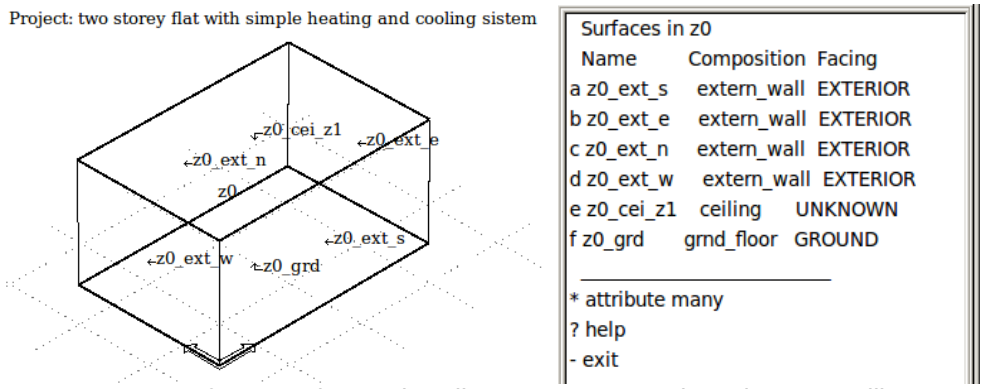


Figure 13: zone z0 surface naming and attributes. Note zo_cei_z1 (zone 0 ceiling connecting to zone 1) stil has the boundary condition unknown as the second zone hasn't been created yet.

5.1 Add a window to a surface

Windows and doors are defined within the surface as a 'hole' to be linked to a vertex of the surface.

Go to Model Management> m browse/edit/simulate >> Browse/Edit/Simulate > c composition>> Zones Composition> a geometry & attribution>> Zone Geometry/Attribution > *(select a zone)*>> Zone 1 Geometry> f surface attributes>> Surfaces in z0> *(select surface)*>> Surface Attributes> + *add glazing/door/opening*

See fig. 14.

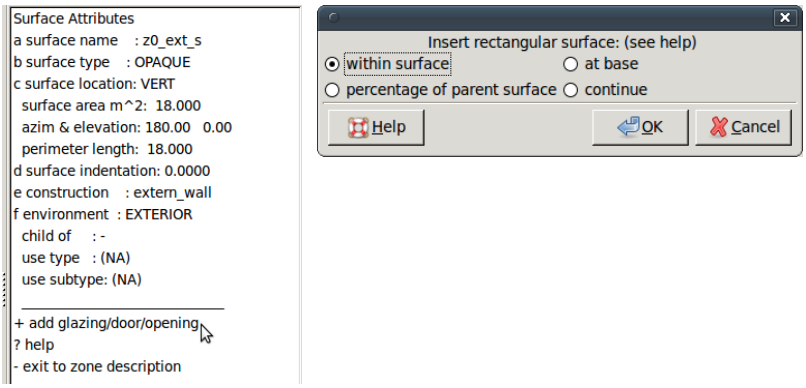


Figure 14: opening geometry menu and options

If insertion is within the surface you will be prompted for an X Z offset from the lower corner (when viewed from the outside), a width and height. The opening width and height are in metres. See fig. 15.

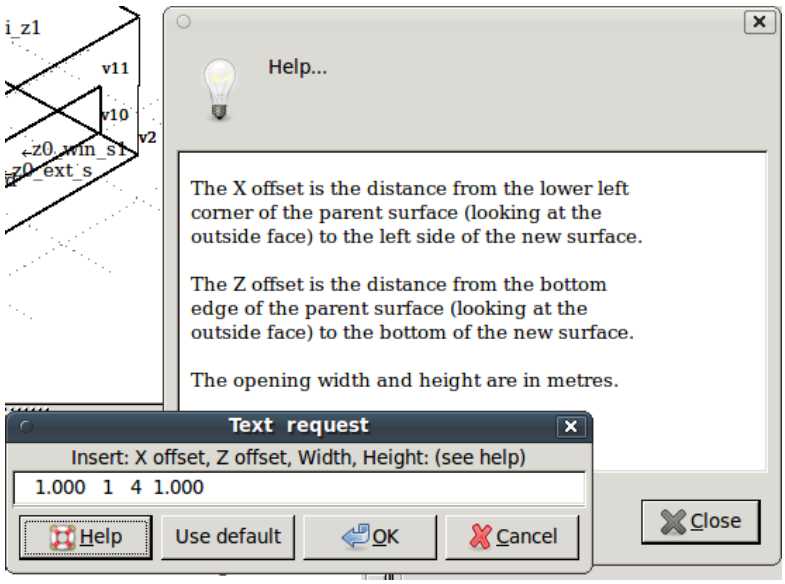

i_z1
v11
v10
v2
z0_win_s1
z0_ext_s
Help...
The X offset is the distance from the lower left corner of the parent surface (looking at the outside face) to the left side of the new surface.
The Z offset is the distance from the bottom edge of the parent surface (looking at the outside face) to the bottom of the new surface.
The opening width and height are in metres.
Close
Text request
Insert: X offset, Z offset, Width, Height: (see help)
1.000 1 4 1.000
Help
Use default
OK
Cancel

Figure 15: coordinates of the window surface

If insertion is `at base` of the surface you will be asked for a X offset from the left lower corner of the surface when viewed from the outside, a width and a height.

If the insertion is a `percentage of parent surface` the opening will be a percentage of the surface and will be positioned at the centre of the surface.

Before confirming the position, check if the position is ok on the wireframe scheme.

See fig. 16. Deleting a window can be a demanding task involving deleting the window surface, the associated vertexes of the parent surface description and the deletion of these vertexes as coordinates.

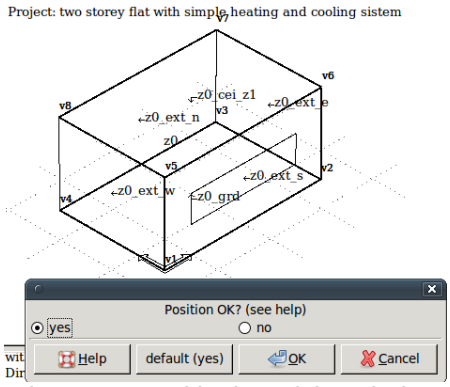


Figure 16: positioning of the window

When prompted for a name try to follow a similar approach to the previous definitions (e.g. z0_win_s).

You will be asked to select a construction for the inserted surface from the database. See fig. 17.

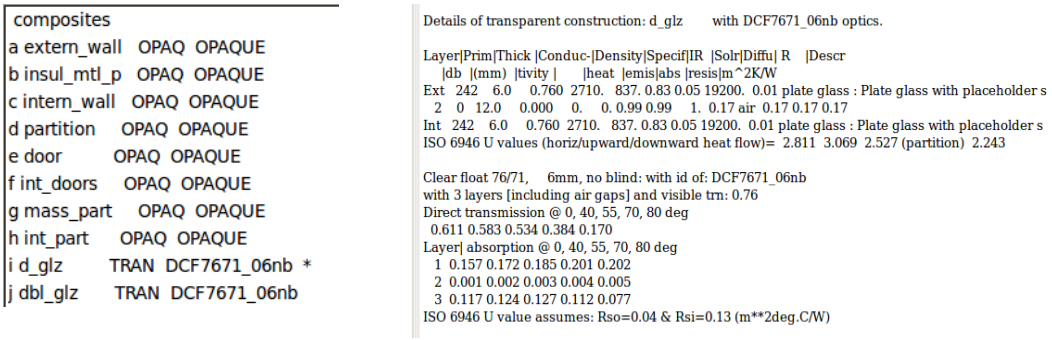

composites
a extern_wall OPAQ OPAQUE
b insul_mtl_p OPAQ OPAQUE
c intern_wall OPAQ OPAQUE
d partition OPAQ OPAQUE
e door OPAQ OPAQUE
f int_doors OPAQ OPAQUE
g mass_part OPAQ OPAQUE
h int_part OPAQ OPAQUE
i d_glz TRAN DCF7671_06nb *
j dbl_glz TRAN DCF7671_06nb
Details of transparent construction: d_glz with DCF7671_06nb optics.
Layer|Prim|Thick |Conduc-|Density|Specif|IR |Solr|Diffu| R |Descr
|db |(mm) |tivity | |heat |emis|abs |resis|m^2K/W
Ext 242 6.0 0.760 2710. 837. 0.83 0.05 19200. 0.01 plate glass : Plate glass with placeholder s
2 0 12.0 0.000 0. 0. 0.99 0.99 1. 0.17 air 0.17 0.17 0.17
Int 242 6.0 0.760 2710. 837. 0.83 0.05 19200. 0.01 plate glass : Plate glass with placeholder s
ISO 6946 U values (horiz/upward/downward heat flow)= 2.811 3.069 2.527 (partition) 2.243
Clear float 76/71, 6mm, no blind: with id of: DCF7671_06nb
with 3 layers [including air gaps] and visible trn: 0.76
Direct transmission @ 0, 40, 55, 70, 80 deg
0.611 0.583 0.534 0.384 0.170
Layer| absorption @ 0, 40, 55, 70, 80 deg
1 0.157 0.172 0.185 0.201 0.202
2 0.001 0.002 0.003 0.004 0.005
3 0.117 0.124 0.127 0.112 0.077
ISO 6946 U value assumes: Rso=0.04 & Rsi=0.13 (m**2deg.C/W)

Figure 17: window construction material

A warning window appears as a reminder of the modifications occurred to the geometry of the zone.

Repeat the process for the following windows.

If a surface has more than one window the bounding surface will be revised to flow around the new 'hole'. You will be asked to provide the corner (left or right) to which link the new 'hole'. If the first `hole` is linked to the lower left corner of the bounding surface, the new surface might link to the lower right corner. This convention will hopefully limit the chance of the edges crossing. Also you will need to list the corner node number. See fig. 18.

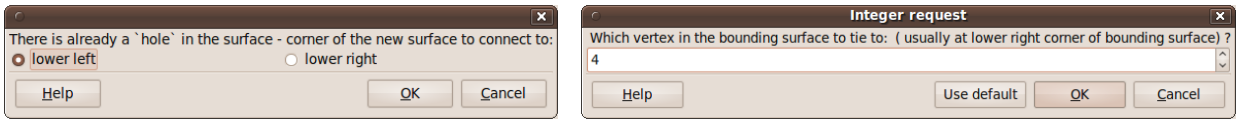


Figure 18: opening geometry menu and options

Don't forget to >save the modifications to update the '***.geo***' file and the '***.con***' and/or '***.tmc***' files. When exit the zone the program will apply for the changes and will create the new files.

NOTE

A maximum of 3 windows can be added to a surface to prevent the it from being too complex. If the position of several windows aren't too significant create a reduced number with the same area. If more than 3 windows are required divide the surface into as many surfaces as needed.

6 CONSTRUCTIONS (mandatory)

After having defined the zone geometry you need to attribute physical proprieties and surface boundaries. Define the composition of surfaces (construction of the wall – select one from the default database, see annex 1 and 2), the type of surface (opaque, transparent – the selection will be made as default with the construction defined) and the environment (exterior, dynamic boundary, surface in another zone, ground adiabatic, ...) condition.

The surface constructions can be defined under the menu Model Management> m browse/edit/simulate>> Browse/Edit/Simulate > c composition>> Zones Composition> a geometry & attribution>> Zone Geometry/Attribution > *(select a zone)*>> Zone 1 Geometry> f surface attributes>> Surfaces in z0> *(select surface)*>> Surface Attributes> ***e construction*** by selecting a composite pre-defined in the construction database. See fig. 19.

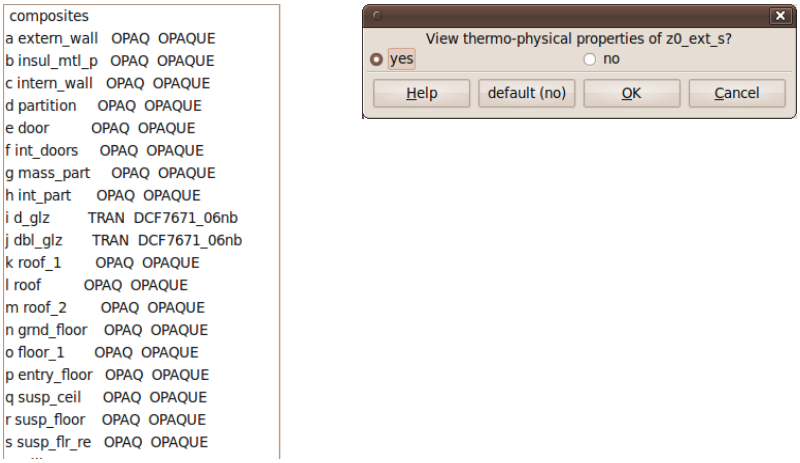


Figure 19: thermo-physical properties od surfaces

However, to create the '***.con***' file for the zone, the constructions should be accessed (at least once) under Model Management> m browse/edit/simulate>> Browse/Edit/Simulate > c composition>> Zones Composition> b construction materials>> Zone constructions and selecting a zone. See fig. 20.

Figure 20: Mandatory construction file

You will be prompted for the name of the zone construction file. By default a path with the zone name plus '***.con***' extension will be suggested. If not found, `create new file using this name.` The program also checks if the transparent constructions are up to date.

One by one the composition of surfaces of the zone will be asked. Select from the database provided and `-exit` to carry on for the following surface construction.

When selecting a surface in another zone you will be prompted to select the other zone and the surface within it to be connected to. If the other side was previous defined as other type of environment you will be asked to update the other side. Although the environment on the other side has changed you will have to go to that surface attribute and change the construction.

Construction layers are defined from the outside to inside order. So when selecting constructions that vary when viewed from one side or the other (e.g. a ceiling) make sure that on the other side of the surface the construction is inverted.

If you already have a construction file you might want to continue with it. Save the `Composition of 'z0'` > `save construction details` to update the '***.con**' and '***.tmc**' construction files. Confirm any update attributes associated with zone geometry to reflect recent changes.

The `Topology Checker` allows to define, update or check the connections and boundaries of the surfaces defined. Run this module to define the surface boundaries or to correct inconsistencies in surface boundaries. Go `Model Management`> `m browse/edit/simulate`>> `Browse/Edit/Simulate`>> `c composition`>> `Zones Composition` > `d surface connections & boundary`>> `S`

Select *`Yes`* from menu options `c to i`'.

Run form the same menu ***`p edit individual connections`*** `or` ***`r check via vertex contiguity`*** or to check all or some contiguities.

Update the surface connections file and accept the default name ***ac.cnn***. Select the zones to be checked from the menu. One by one all the surfaces, according to our previous selection, will be checked. When an inconsistency is found you will be asked to define the boundary. Also when no geometric match is found, e.g. External surfaces, you will be asked to confirm the type.

Save the new topology and exit the `Surface Connections & Boundary`.

In the `Model Management` or ithe `Browse/Edit/Simulate` menu confirm the update of the new configuration to the system file ***ac.cfg***

7 OPERATION (mandatory)

This module deals with the internal gains inside a zone. These can be occupants, lights or equipment. It provides schedules for the different casual gains on weekdays, saturday and sunday periods on hourly intervals.

This module also deals with air flows, infiltration and/or ventilation rates on the basis of ACH (air changes per hour) or cubic meters per second defined by the user. It provides schedules for both infiltration and ventilation on similar scheme to the ones defined for the casual gains. Also it allows the air flow to be thermostatically controlled with 3 set points.

When you select the operations menu for the first time (operations undefined) you may provide initial casual gain period start times. That applies for each day type (weekday, saturday and sunday) and for each casual gain type (occupancy, lights and small power). You still have to define the potency correspondent to the previously defined periods. Alternatively ignore the period start times and insert manually periods, gains and fraction distribution.

NOTE

Air flows are defined via one or more sequential periods, the magnitude at a given time being the flow specified a period that includes that time.

In cases where ventilation will occur with more than one modelled zone then a fluid flow network or temporal definition file should be employed.

Note that large changes in flow rates between periods can result in unacceptable interpolation errors.

The add/delete/copy/import option are as follows:

add - adds a period to one or all day types. BE SURE to read the extended help messages in this dialogue to understand how to use the add function to insert a period into a profile.

delete - deletes one or more periods (within a list of all periods in all days).

copy - copies Weekdays to Saturdays or Weekdays -> Sundays or Saturdays -> Sundays

import - copies infiltration, ventilation and control (or a subset of these data) from another zone.

When importing you can specify whether to:

a) preserve the ac/h being imported, e.g. 1.5 ac/h in the source zone is 1.5 ac/h in the destination zone;

b) preserve the volume of air implied by the ac/h in the source zone, e.g. 1.5 ac/h in a 50m^3 source zone becomes 1.07 ac/h in a 70m^3 destination zone.

To define the operations related to the internal gains and airflow of a zone, select Model Management> m browse/edit/simulate>> Browse/Edit/Simulate> c

composition> Zones Composition> c operational details> Zone Operations Selection> *(select a zone)*

If the file ***.opr** is still not found. See fig. 21.

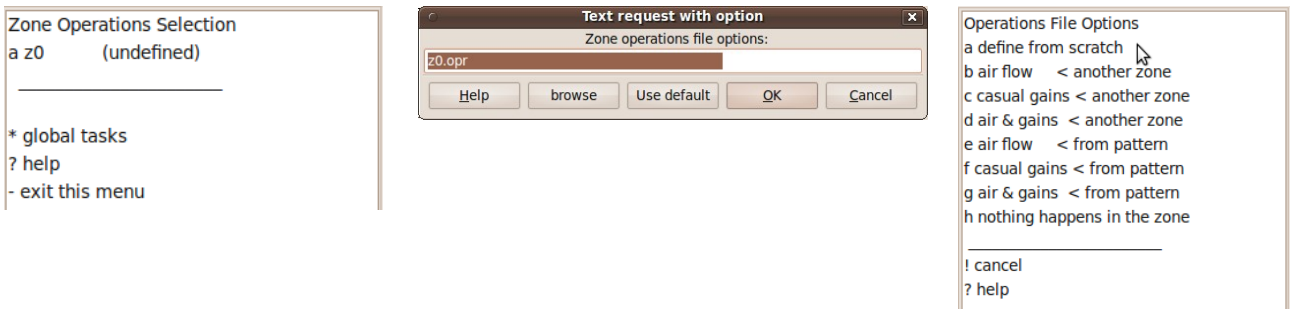
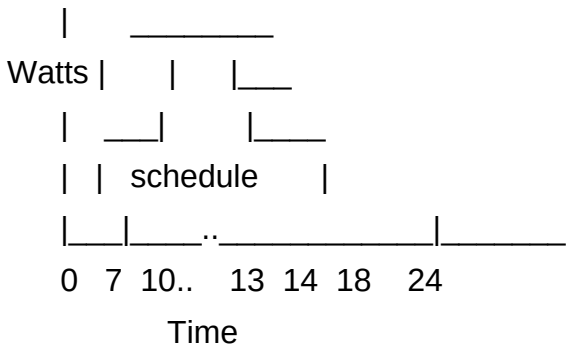


Figure 21: Operations file

NOTE

New operations for this zone. Please check your notes and provide initial casual gain period start times for each day type (Weekday, Saturday, Sunday etc.) and for each casual gain type (occupants, lighting and small power). Do not include periods to be imported from events profiles.

Example of a schedule including 6 periods:



The default assumption is that there is one period (from 0h00 to 24h00) with zero sensible and latent gains for each casual gain type on each day type.

This ensures that nothing is happening in the zone until you provide relevant information (e.g. insert at least one period and define a casual gain).

You will be required to define the casual gains (occupancy, lights and small power) for each day type (weekday, saturday and sunday), their periods of activity and starting times. Correspondent gains will be defined for each period. Select for day type *weekday* the *number of casual gain periods* for each gain type and each *starting times*. See fig. 22. Repeat the process for day types Saturday and Sunday.

The default assumption is that there is one period (from 0:00 to 24:00) with zero sensible and latent gains for each casual gain type on each day type.

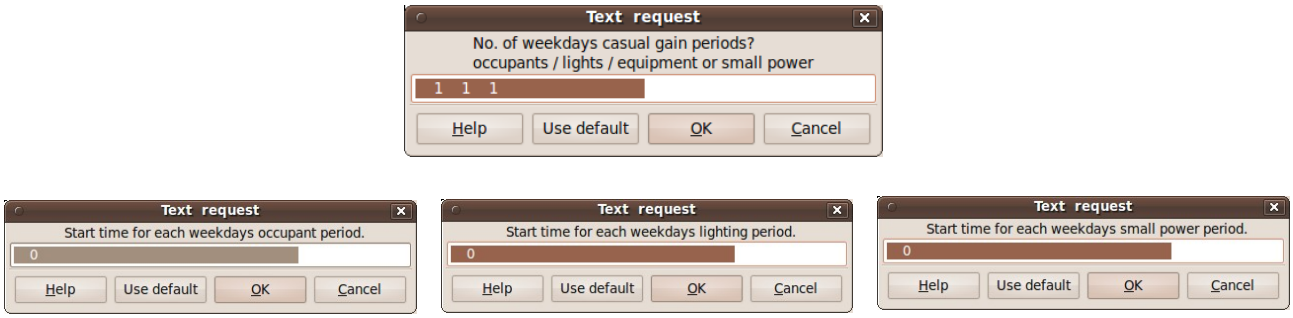


Figure 22: Operations file start times and periods

For each day type add a period and define the respective gain in terms of sensible and latent gain and the radiative and convective fractions. See fig. 23 for occupancy gains.

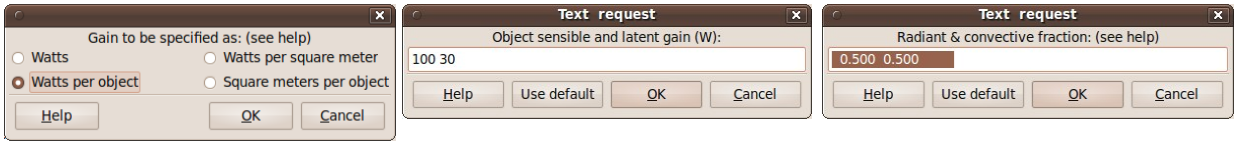


Figure 23: Occupancy gains

Consider the following internal gains:

- Occupancy: 2 occupants on the weekday period from 9 till 18, on a sedentary activity – seated light work - as 110 Wperson-1 of sensible gain and 30 Wperson-1 of latent gain with a 0.5 radiant and 0.5 convective fraction.
- Lights: fluorescent type as 4 Wm-2 of sensible with a 0.3 radiant and 0.7 convective portion for a weekday period between 16 and 18.

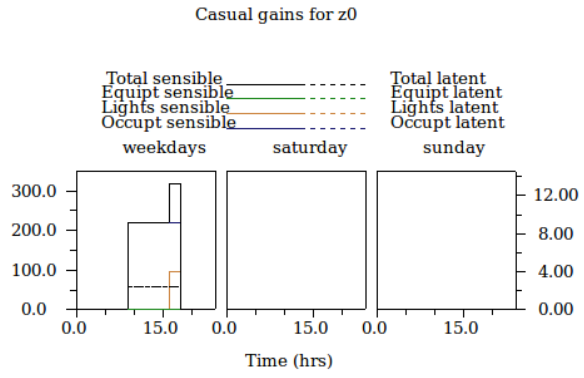


Figure 24: casual gains distribution

Before you leave the casual gains section and in particular if you have defined just the periods with casual gains do not forget to check/remove period overlaps to guarantee the the 0 to 24 hours for every day and gain types. Select Model Management> m browse/edit/simulate>> Browse/Edit/Simulate> c composition> Zones Composition> c operational details> Zone Operations

Selection> *(select a zone)*> Zone operations> d edit casual gains > Casual gains in z0 > # check /remove overlaps

A similar approach is used for defining the schedule air flow of a space, by setting the periods of operation and their rates. See fig. 25.

To define an infiltration and ventilation, select Model Management> m browse/edit/simulate>> Browse/Edit/Simulate> c composition> Zones Composition> c operational details> Zone Operations Selection> *(select a zone)*> Zone operations> c edit scheduled air flows>> *Air flow in 'z0'* +add/delete/copy air flows

Consider a permanent infiltration of 0.5 ac/h.

The program considers infiltration the air flow between a zone and the outside and the ventilation the air flow between zones.

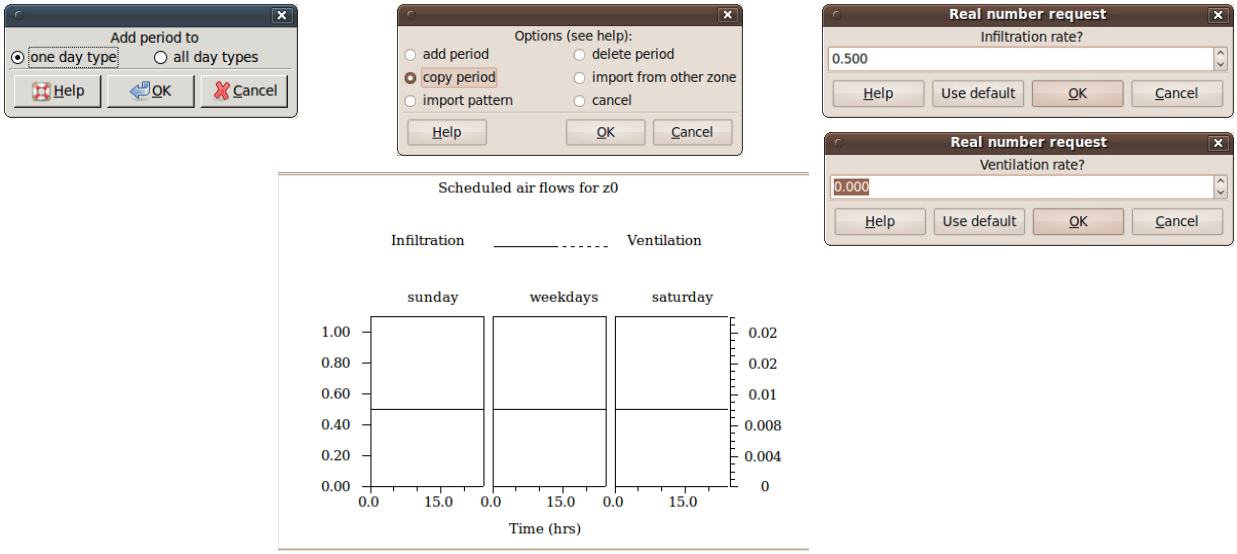


Figure 25: Air flow permanent infiltration rate

Before exiting the ***Zone Operations > Save air flow & casual gains.***

If the operation file (.opr) already exists carry on from

Zone Operations> (select a zone)> Zone operations>

c edit schedule air flow> Air flow in z0

or

d edit casual gains> Casual gains in z0

specifying different periods and corresponding gains.

Even if there are no casual gains or air flows, the '****.opr***' must be created. Go

Model Management> m browse/edit/simulate>> Browse/Edit/Simulate> c composition> Zones Composition> c operational details> Zone

Operations Selection> *(select a zone)*> Operations file options Zone operations> h nothing happens in this zone

After the definition of the operations the mandatory files are created and you will be able to run a simulation.

Before you run a simulation you should save your model under Model Management> m browse/edit/simulate>> Browse/Edit/Simulate> ! Save model to make sure the last alterations are taken into consideration.

8 SIMULATION

To run a simulation select Model Management> m browse/edit/simulate > Browse/Edit/Simulate > q simulation> Simulation Controller> a simulation presets and proceed with the parameter definition.

Under the name for set chose year

Under this module select g from to assess the period of the simulation. As this model is quite simple, you can run it for the whole year (from 1 1 till 31 12). Otherwise, try to select periods that might be pertinent but run a minimum of 7 days to take into consideration the construction heat storage. See fig 26.

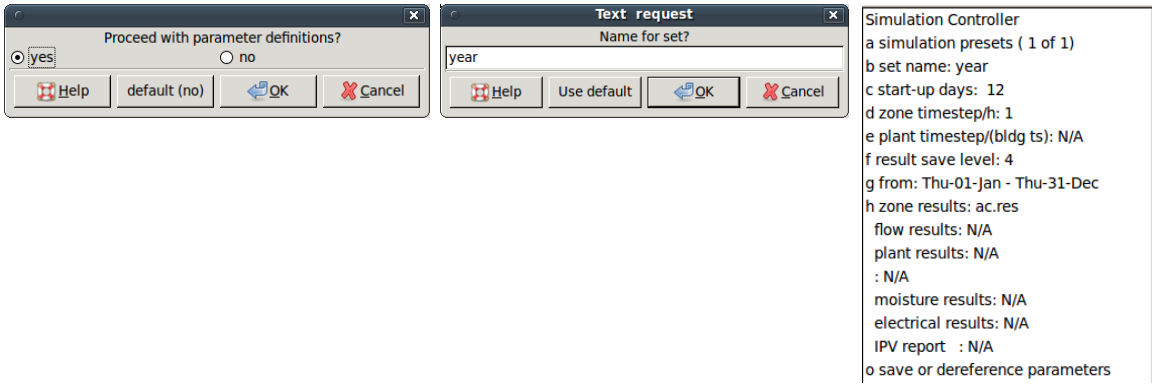


Figure 26: Air flow permanent infiltration rate

You can also store a winter preset as win from (day) 5 (month) 1 till 11 1 and a summer one as sum from 1 8 till 7 8.

It is also in this menu that you should define the name of the file and path to the directory were you want your results to be saved.

Select > p integrated simulation> Simulation interaction options: run silent. See fig. 27

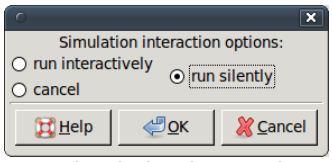


Figure 27: Simulation interaction options

When the simulation finishes you will return automatically to the Browse/Edit/Simulate menu.

If the zone results path is not inserted, for the run in silent mode, the program saves the results file ***.res** on the directory were ESP-r was launched on the command shell. For the run interactive, the program will forward the ***name_of_file.res*** results file to the ***cfg*** directory (option with set of folders).

9 RESULT ANALYSIS

You will be able to access the results from the simulation under Model Management > m browse/edit/simulate > /Browse/Edit/Simulate r result analysis to open the module ESP-r Results Analysis.

The library name '***.res**' file should be available for selection.

As your simulation doesn't have any plant or system defined you will only analyse the climate parameters, the temperature in the zone, the flux transfer (gain/losses) on the building surfaces and casual gains.

To view graphs select results analysis> a Graphs> Graphs facilities> a Time: var graph> Time series plot

Select a Climate>Climate choices:> a Ambient temperature and b Temperatures> any temperature option i.e. a Zone db T . To visualise these two variants in the same graph select ! draw graph.

All variables selected will be add to the previous graph. To clear all variables select / Clear all selections to clear some variables previous included select q Edit selections and disactivate the variables to be removed and ! draw graph.

10 DATABASE MODIFICATIONS

As previously explained ESP-r contains databases of materials (constr.db1) and layered constructions (multicon.db1) that can be used for defining the thermo-physical proprieties of the model surfaces. However, these databases can not be modified by you. To add materials or modify/create new constructions you will have to make a copy of the database file and save it in your home directory.

For modifying either materials or constructions go to the menu Model Management > b database maintenance> Database Maintenance select the database (e.g. e constructions)> Constructions db > d *copy of db.* The new construction database will be renamed (default name of project) and located in the ***/dbs*** or in the

unique directory of your project.

Now you can edit the new database or access it later by selecting it from the Databases menu. Under this menu you can now notice a change in the path of the database. All the others that maintain the default path ***/usr/esru/esp-r/databases*** can only be read but not written to. Even if you think you have made modifications to them, they retain the original content.

When you edit the constructions database you will be able to browse or edit, select, create or copy a construction database. Within the construction ! add or delete a layer. Pay attention that for constructions of interior surfaces that have nonsymetric layers you should create as well an inverted construction and link it to the one which has 'inverted' layers. Before exit the database don't forget to `> save database`.

Esp-r allows Climate data import from de EnergyPlus database at

http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

After downloading e extracting the archive file you will need to convert the *.EPW file to a binary one.

On a command line type

```
clm -mode text -file FIN_Helsinki -act epw2bin silent
FIN_Helsinki.029740_IWEC.epw
```

You can them `Model Management > b database maintenance>> Database Maintenance a annual climate>> Climate db > b select another db>> Climate sets > <user climate db`

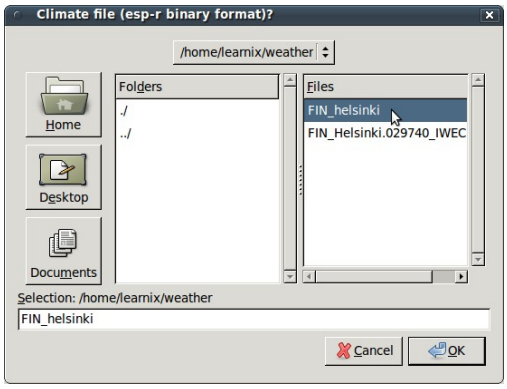


Figure 28: Importing Climate file

Browse the Climate database to make sure it was imported correctly.

Do not forget to update the Latitude and Longitude of the location be consistent with the climate data. Go

`Model Management > browse/edite/simulate > Browse/Edit/Simulate > b model context > Model Context > a site latitude and b longitude difference`

Update the shading distribution as in fig. 29. Rebuild the construction files to update any changes made in the materials and construction Databases.

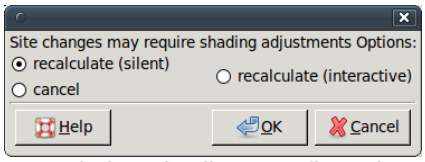


Figure 29: Updating shading to reflect site changes.

11 A SIMPLE HEATING/COOLING CONTROL

ESP-r is a general simulation tool which may be used to address a broad range of thermal performance questions.

The most common problem type involves the prediction of flux movements, comfort and/ or energy demands within the fabric of buildings. Many such problems are adequately represented via ideal control systems and imposed air movement regimes.

You will now create a simple control loop and connect it to a zone of the model.

For each day type (weekday – 1, Saturday – 2 and Sunday – 3) a number of control periods will be defined.

The control will be set to sense the zone air drybulb temperature.

For the periods without occupancy the control will be free-float. For the remaining periods the control will be activated when the drybulb temperature drops below or exceeds the defined heating and/or cooling setpoint.

Select `Model Management>` `m browse/edit/simulate>>` `Browse/ Edit/ Simulate>` under `Controls` select `j zones`. If there is currently no control associated with the model create one. The file will be located in the model folder or in the ***/ctl*** folder (on multiple directories) with the model name and extension '****.ctl****'.

You will be asked to define the type of days related to the control. Select the `weekday/Saturday/sunday` to be able to set up different controls for those three days type. See fig. 30.

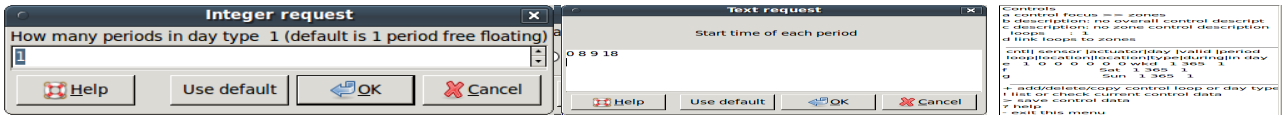


Figure 30: setting of the zone control. Day types, periods and start time.

For day type 1 (weekday) select 4 periods. You will be asked for the starting times for each period. For days type 2 (saturday) and type 3 (sunday) select 1 period with a free floating controller.

It is not necessary to define the exact number of periods as they can be added later in the following menu.

These day types and periods will allow the control to be switch off during the weekend

days and during the night on weekdays.

When accessing the control file at the second time do not select `dereference` as this option will clear the name of the control file but does not alter information within the control description. You can re-establish control by including the control file name. As default the path of the model redirects to the folder ***/cfg***. To access the ***/ctl*** which is in same directory level type **`../ctl/filename.ctl.`** For the location of the file with the single directory no paths are necessary.

When asked if are there any nested control functions select **no**. See fig. 31.

Under the `Controls` select the weekdays (wkd) period to go to menu `Editing options` and select the following options:

`> a sensor details>` `Zone sensor` as `a senses current zone db temp`;

`> b actuator details>` `Zone actuator` as `a at current zone air point`;

`> c period of validity` set it for the whole year;

`> d period data >` `Control periods` for each period selected, chose the control law.

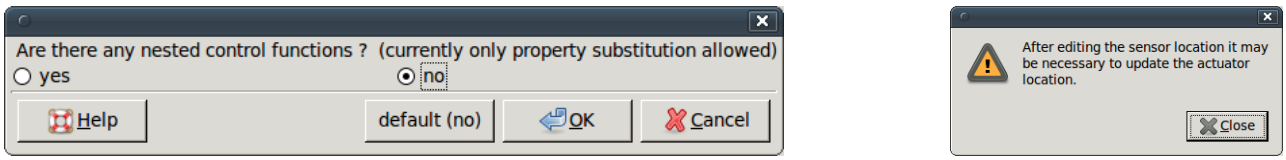


Figure 31: zone control parameters.

To define an active system during the occupancy hours, 3 periods would be enough. However, it is best practice to start the system a short period before people arrive on a less tight set point temperature or on a lower power. For that reason 4 periods are ideal.

If no control nor power supply is defined select under the `control law`> `b free-float controller`. You will be asked the `period start time`. That law stands until the following period starts. Define the first period as such.

You can set a short period where the system will start on pre-run, usually an hour before the arrival of the occupants. Set a lower capacity than expected. The following period can also have the same control law but high heating or cooling capacity. It will start at the same time defined for the occupancy. See fig. 32.

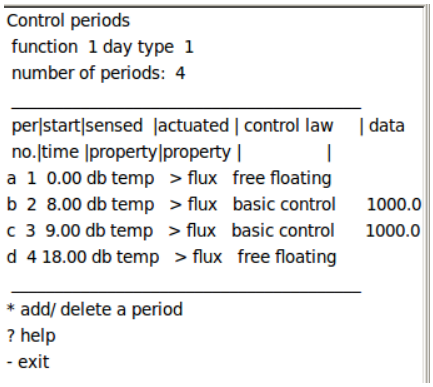

Control periods
function 1 day type 1
number of periods: 4
per|start|sensed |actuated | control law | data
no.|time |property|property | |
a 1 0.00 db temp > flux free floating
b 2 8.00 db temp > flux basic control 1000.0
c 3 9.00 db temp > flux basic control 1000.0
d 4 18.00 db temp > flux free floating
* add/ delete a period
? help
- exit

Figure 32: y type at start time periods for the control.

A simple control can be selected under control law> a basic controller for heating and cooling, with start times, maximum heating and cooling capacity, minimum heating and cooling capacity, and heating and cooling setpoints as shown in fig. 33.

Set a maximum heating and cooling capacity of 2000 W each and a minimum of 0.

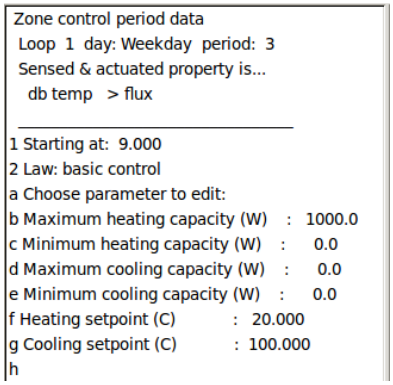

Zone control period data
Loop 1 day: Weekday period: 3
Sensed & actuated property is...
db temp > flux
1 Starting at: 9.000
2 Law: basic control
a Choose parameter to edit:
b Maximum heating capacity (W) : 1000.0
c Minimum heating capacity (W) : 0.0
d Maximum cooling capacity (W) : 0.0
e Minimum cooling capacity (W) : 0.0
f Heating setpoint (C) : 20.000
g Cooling setpoint (C) : 100.000
h

Figure 33: zone heating and cooling temperature control start at 9am.

The following definition is regarding the heating and cooling setpoints. If no cooling is required set max power to 0 W, and a cooling setpoint to an impracticable temperature (ex. 100°C). With this you do not want to control the zone humidity. See fig. 34.

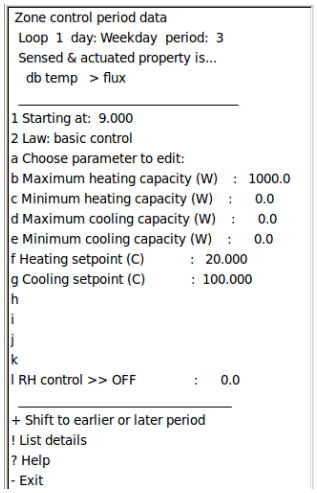

Zone control period data
Loop 1 day: Weekday period: 3
Sensed & actuated property is...
db temp > flux
1 Starting at: 9.000
2 Law: basic control
a Choose parameter to edit:
b Maximum heating capacity (W) : 1000.0
c Minimum heating capacity (W) : 0.0
d Maximum cooling capacity (W) : 0.0
e Minimum cooling capacity (W) : 0.0
f Heating setpoint (C) : 20.000
g Cooling setpoint (C) : 100.000
h
i
j
k
l RH control >> OFF : 0.0
+ Shift to earlier or later period
! List details
? Help
- Exit

Figure 34: zone with heating and no cooling temperature control start at 9am.

The last period will be similar to the first one, with a free float law. Its start time coincides with the time when the occupants leave the space.

Before you leave the menu Controls you will have to link the control to the thermal zones. Select d link loops to zones and attribute the loop number to one of the zones. Leave the other without control (0). Don't forget to > save control data.

12 SIMULATION

You have previously run a simulation with presets. Now, you will run it interactively to alter if desired the default presets and to monitor state variables (e.g. Temperature).

Although the program does not create any specific directory to store the results, it is a good practice to store these files on a specific directory. They are the biggest files created and you want to store them were you have enough disk space. Remember that you will have to redirect the ****.res*** file to that directory. Alternatively, you can set the path to it on `Simulation controller> h zone results: ac.res`

If you run the simulation in silent mode the previous results will be overwritten by default. The directory were the results are redirected by default will be the directory were you lauched the ESP-r software in the command line of the bash shell.

On an interactively run you will be asked if you want to store previously run results. If you decide to continue with the defaults, the results will be forward to the ***/cfg*** directory of the project. The least confusing approach will be to launch a model already defined under the directory ***cfg*** as said before.

Go `Model Management>> m browse/edit/simulate>> Browse/Edit/Simulate > q simulation> Simulation controller> p integrated simulation>`

`Simulation interaction options: run interactively`. You will be prompted for the system configuration file, the simulation start-up period and the climate file. Under `ESP-r integrated simulator > c initiate simulation`. You will be prompted for the results library name and to whether preserver or not previous results. Then for the simulation period and time-steps. Under `SIMUL > m Monitor state variables`

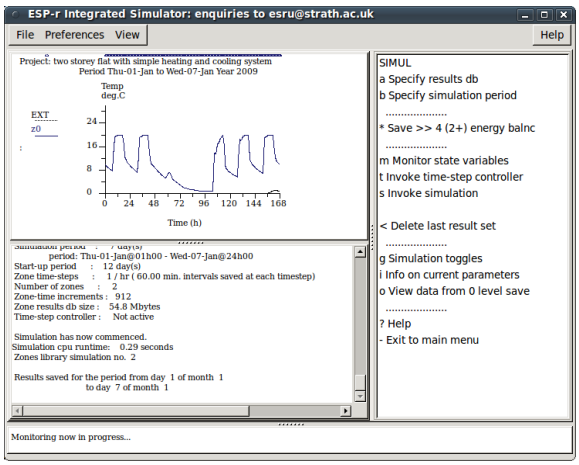

ESP-r integrated Simulator: enquiries to esru@strath.ac.uk
File Preferences View
Help
Project: two storey flat with simple heating and cooling system
Period Thu-01-Jan to Wed-07-Jan Year 2009
Temp
deg.C
EXT
z0
24
16
8
0
0 24 48 72 96 120 144 168
Time (h)
period: Thu-01-Jan@01h00 - Wed-07-Jan@24h00
Start-up period : 12 day(s)
Zone time-steps : 1 / hr (60.00 min. intervals saved at each timestep)
Number of zones : 2
Zone-time increments : 912
Zone results db size : 54.8 Mbytes
Time-step controller : Not active
Simulation has now commenced.
Simulation cpu runtime: 0.29 seconds
Zones library simulation no. 2
Results saved for the period from day 1 of month 1
to day 7 of month 1
SIMUL
a Specify results db
b Specify simulation period
* Save >> 4 (2+) energy balnc
m Monitor state variables
t Invoke time-step controller
s Invoke simulation
< Delete last result set
g Simulation toggles
i Info on current parameters
o View data from 0 level save
? Help
- Exit to main menu
Monitoring now in progress...

Figure 35: Monitor variables during the run of simulation.

`>(monitor)` select a zone of interest and `– Exit`. Select `temperature and/or plant flux` and define a `Minimum and maximum values` for the scale of the graph. Again in the previous menu select `s invoke simulation` and answer to name of the control file and a results-set description. The simulation will start with the monitored selection on a graph. When finished you will have to save the results. See fig. 35.

13 RESULTS – Enquire about

You will be able to access the results from the simulation under `Model Management`>> `m browse/edit/simulate>>` `Browse/Edit/Simulate` `> r result analysis.`

You learned in the last lesson how to access the graphical analysis facilities.

Today, go under the `results analysis`> `d Enquire about>>` `Enquire about` to see the following text results:

```
> f energy delivered
> g casual gains distribution
> h zone energy balance
> i surface energy balance

>a summary statistics
> c hours above a value
...
```

The output results will be send to the text window.

There are some options how to save the results on a format accessible by other applications. You can select and copy the text and past it to a word package, like open office. Under the `Enquire about` menu `> output >> screen` can be changed to a user defined file name in either the model folder or in an user defined folder. Until deselected again all the selected results will be sent to this file.

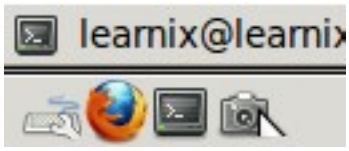


Figure 36: screen-shot program icon.

Graphics can also be saved by taking a screenshot. See fig. 36. You can select the area to grab, the whole desktop or the current window. Alternatively data can be exported to a file and later imported into a spread sheet.

14 AIR FLOW NETWORK

The second model to be defined will have natural ventilation (NV) instead of an air conditioning system (AC).

As the geometry and the occupancy are the same you can copy the existing model and rename it ***nv***.

To avoid confusions with the two models copy the directory ***ac*** (and the inside subfolders) to ***nv***. Rename the file ***ac.cfg*** in the directory ***cfg*** of the ***nv*** model to ***nv.cfg***. For any other file that you rename (ex. ***nv.cnn***) you need to edit the new ***nv.cfg*** file and update its

name. Alternatively you may change the files names within the project manager and the program will update its names in the configuration file (***.cfg***) when you save.

Launch the new esp-r model. Remember to be in the directory ***cfg*** or in the model directory where the file is located.

In the ***Model Management*** < g root change the root name to ***nv***. All the new files created will take this name as default (with the corresponding extension).

In a naturally ventilated building you will not consider any cooling load therefore if you had previous set an heating and cooling power you will have to delete the control loop or set the cooling capacity to 0 or define a cooling setpoint to an excessive temperature (ex 100°C). The shown control file (***NV.ctl***) adopts the last option. See comment 1 on page 60.

Go to Model Management>> m browse/edit/simulate >> Browse/Edit/Simulate >> (Controls) j zones > Controls >

(select the control loop type to alter) > Editing options> d period data> Control periods> (select the period with cooling to alter) > control law> *a Basic controller for heating/cooling* set the controller as before but change the cooling temperature setpoint tp 100°C. Do not forget before leaving the Controls menu to > save control data.

Control file?

Change the name of the control to ***nv.ctl***. Instead of ../ctl/ac.ctl type ../ctl/nv.ctl

Exit the controls and save the model to update the configuration file. You may want to change the Surface connections file name? to ***nv.cnn*** to have the new **nv** model with all the files associated to this name. Later when you are more familiar with the program you may copy the configuration file to a new file and just change the files that you modify.

Previously you have created and infiltration and ventilation imposed by a user defined ACH. Now you will define a mass fluid flow which is governed by a flow network. That means that instead of a volume change defined, you will address external and internal conditions and the opening where the fluid (air) passes due to differences of temperature and pressure.

Your network will consist of nodes, components and connections, governed by a control law that defines the conditions to the strategy imposed.

You will then have to define two types of nodes:

- external - defined by an height above ground, an azimuth (clockwise from north), a boundary and pressure characteristic;
- internal - defined by an height above ground, a temperature condition and an association with a zone.

Each floor is recommended to have a minimum of 3 nodes, two external and one internal.

Don't forget to link the internal nodes to the zones.

The air movement is restricted between the nodes (external < > internal) via crack openings (around windows) and open windows. You will have to create these

components. For these components you will have to define the type & description such as air flow crack or air flow opening and width, length or area of the 'hole'.

Thirdly you will have to define the connections between the nodes via the components.

If you want to define a window opening for passive ventilation (say to open above a certain temperature) you will have to create a control for ventilation. You will have to create a loop that senses the temperature in a zone and defines a control strategy for certain periods and temperature setpoints. You will also have to address an actuator that connects to a previous defined component (window).

Begin the network description by specifying a few nodes, components and connections.

Model Management>> m browse/edit/simulate >> Browse/Edit/Simulate
e network flow

Define air flow via: flow network (menu)

Flow network file? nv.afn: ok

File not found. Options: make new file

Is the new network: all air See fig. 37.

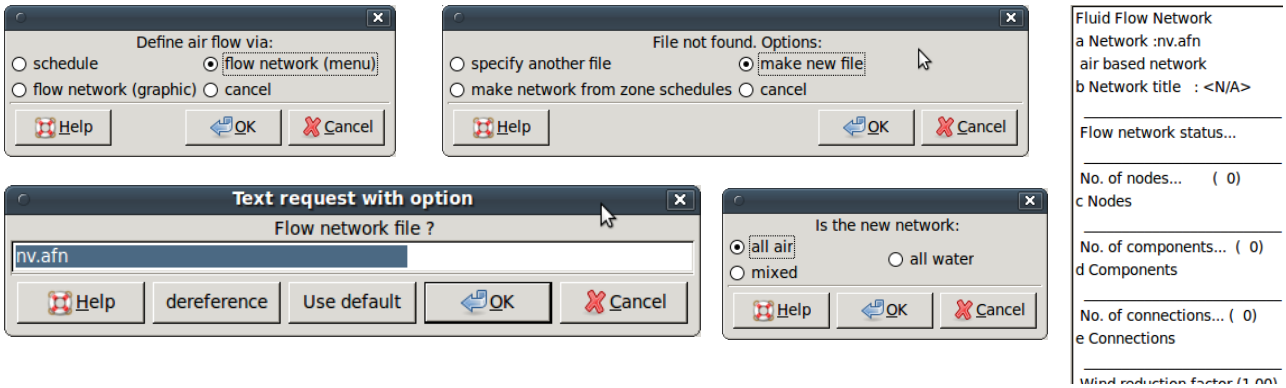


Figure 37: Set up of the flow network.

NOTE:

- The description of a flow network begins with the description of flow nodes. A functioning network must have at least 3 nodes.
- You can select the zones to be included in the network. The program will then generate the internal nodes associated with those zones for you. It also generate internal connections between the nodes in your network, but you should define the linking components (doors, vents) first.
- REMEMBER to include boundary nodes in your network.
- These are NOT auto generated at the moment. Also remember to connect them into your network.

Fluid Flow Network**> c Nodes>**

Do y**ou want to auto-**generate flow nodes? Yes

You will be asked which zones to include in the fluid flow network. Select just one (z0) for

NOTE: You now have the option of automatically generating flow nodes from the building description. Select the zones you wish to include in the flow network and a corresponding flow node will be generated with the same name.

this simple model. The internal node of zone z0 is created. It is localised as default in the middle of the space.

If you edit the internal node you will have to define:

node name keep the default zone name

node type & pressure: internal:unknown (node describing a volume of air inside a zone where the pressure and temperature of node are unknown and is solved at each time step). See fig.38.

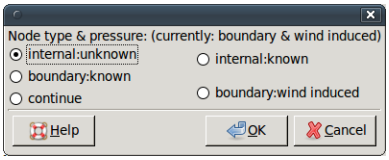


Figure 38: Node type and pressure.

Associate the node with its zone, confirm its volume and height in reference to the coordinate system of the building.

You will be asked the node temperature, set initial or constant value to 20 degrees. See fig. 39.

NOTE: The initial temperature is the temperature assumed for the node at the beginning of the simulation. If the flow network is part of a thermal model then this temperature is updated with calculated values as the simulation progresses. Otherwise this value is fixed as the nodal temperature.

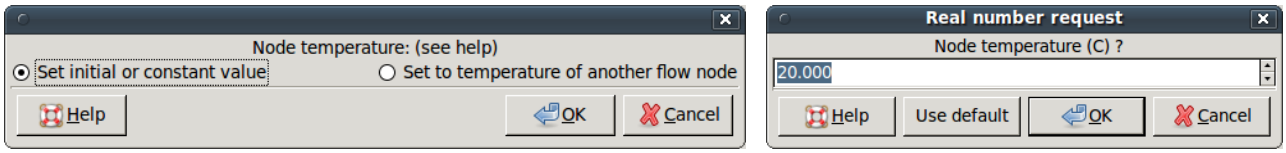


Figure 39: Node initial temperature

If '`Set to temperature of another node`' is chosen then this node will pick up the temperature of a designated node.

Continue by creating an external node on the north side. Name it `ext_north` and select `boundary:wind induced` (node describing the conditions at the boundary of the network. The pressure of this node is generated by the wind impinging upon a surface. The pressure is a function of wind velocity, wind direction and a pressure coefficient, CP, assigned based on the orientation and geometry of the surface, as P=P(V,D,CP))

NOTE: You have selected a wind-induced pressure node: wind impinging upon, or flowing over a surface creates a pressure difference with the inside of the building, driving infiltration and exfiltration through any openings in that surface.

You should select the zone and surface subjected to this wind pressure.

NOTE: to enable the calculation of wind-induced surface pressures (as required by ESP-r's fluid flow simulators), a database of angle dependent pressure coefficients is provided.

The default ESP-r set contains wind pressure coefficients for surfaces in typical positions and within several different exposure categories. They can be used (with care) for low-rise buildings. See the ESP manual for additional info.

It is also possible to calculate pressure coefficients using CpCalc (see database maintenance).

```
Select the zone containing the surface. (No previous zone defined) z0
```

```
Select the surface subjected to the wind pressure: z0_ext_n
```

```
Select the pressure coefficient set which best matches this surface. (see help) u 2:1 semi-exposed short wall
```

Select the pressure coefficient from the list, which is most appropriate for the location of the external node.

```
Use 2:1 semi-exposed short wall as the pressure coefficient set? Yes
```

```
Surface azimuth angle (degrees clockwise from north): 0
```

```
Node reference height above datum (m)? 1.5
```

See fig. 40.

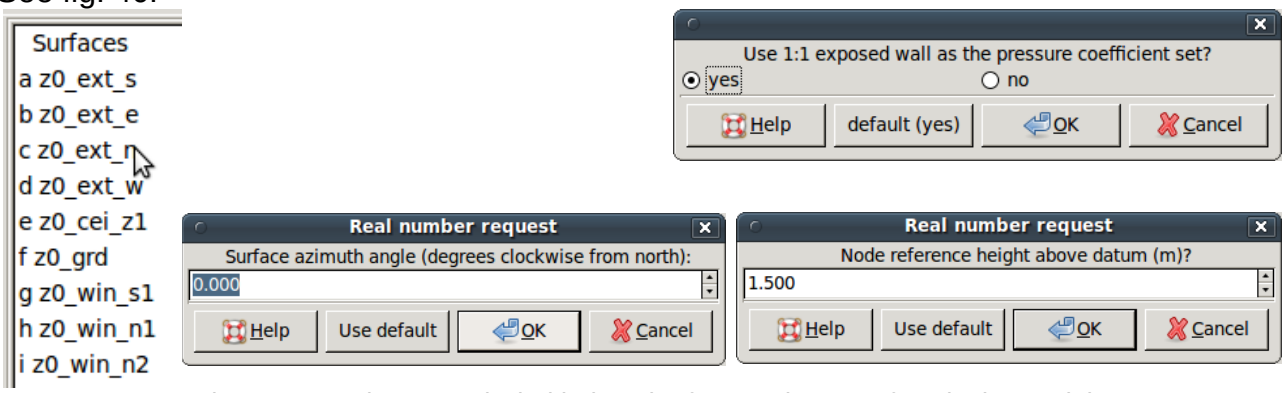


Figure 40: Node external wind induced referenced to a surface in the model

NOTE: The height is used to support buoyancy calculations. Height is defined as the height above some arbitrary datum usually ground level (height=0.0m).

Repeat the process for the external node on the south side. See fig. 41.

Don't forget to go `Fluid Flow network> g Link nodes and zones`

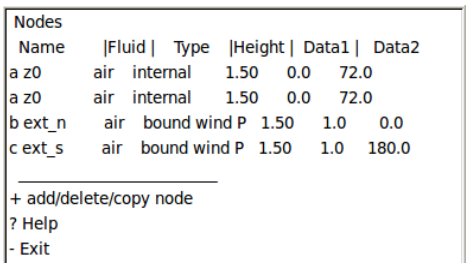

Nodes
Name |Fluid | Type |Height | Data1 | Data2
a z0 air internal 1.50 0.0 72.0
a z0 air internal 1.50 0.0 72.0
b ext_n air bound wind P 1.50 1.0 0.0
c ext_s air bound wind P 1.50 1.0 180.0
+ add/delete/copy node
? Help
- Exit

Figure 41: Network flow nodes.

Then define the Components.

Fluid Flow network> d components

+add a component

Component name: win_crk_s (window crack south)

Component type & description> 120: Specific air flow crack

Specific air flow crack Synopsis of this component type? Yes

NOTE: Supplemental data: (1)fluid type (air only) (2)crack width (mm) (3)crack length (m)

Crack width (mm) and length (m)? 5 2

See fig. 42.

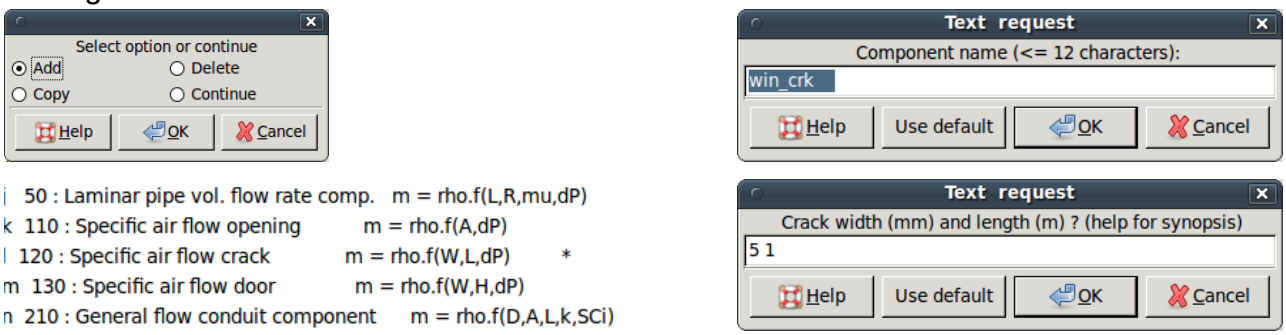

Select option or continue
Add
Delete
Copy
Continue
Help
OK
Cancel
Text request
Component name (<= 12 characters):
win_crk
Use default
Text request
Crack width (mm) and length (m) ? (help for synopsis)
5 1
j 50 : Laminar pipe vol. flow rate comp. m = rho.f(L,R,mu,dP)
k 110 : Specific air flow opening m = rho.f(A,dP)
l 120 : Specific air flow crack m = rho.f(W,L,dP) *
m 130 : Specific air flow door m = rho.f(W,H,dP)
n 210 : General flow conduit component m = rho.f(D,A,L,k,SCi)

Figure 42: Network flow component window crack.

Add a second one similar for the window crack on the north facade but with a different area. See fig. If the cracks are the same size on both facade there is only the need for one component, which is utilized on the different connections.

Add another one as window Component

component name: win_open

component type & description >110 : Specific air flow opening

and define Opening area of window (m^2)? 2 See fig. 43.

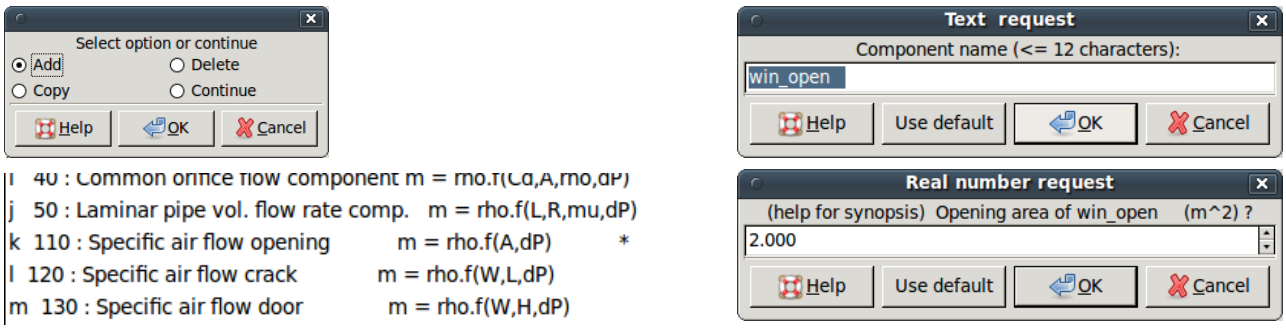

Select option or continue
Add
Delete
Copy
Continue
Help
OK
Cancel
Text request
Component name (<= 12 characters):
win_open
Use default
Real number request
(help for synopsis) Opening area of win_open (m^2) ?
2.000
j 50 : Laminar pipe vol. flow rate comp. m = rho.f(L,R,mu,dP)
k 110 : Specific air flow opening m = rho.f(A,dP) *
l 120 : Specific air flow crack m = rho.f(W,L,dP)
m 130 : Specific air flow door m = rho.f(W,H,dP)

Figure 43: Network flow component window opening.

! Save Network

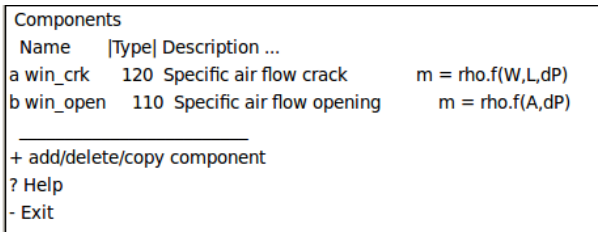

Components
Name |Type| Description ...
a win_crk 120 Specific air flow crack m = rho.f(W,L,dP)
b win_open 110 Specific air flow opening m = rho.f(A,dP)
+ add/delete/copy component
? Help
- Exit

Figure 44: Network flow components.

Then do the connections:

Fluid Flow Network > e connections

do not auto generate connections, set them manually. See fig. 45

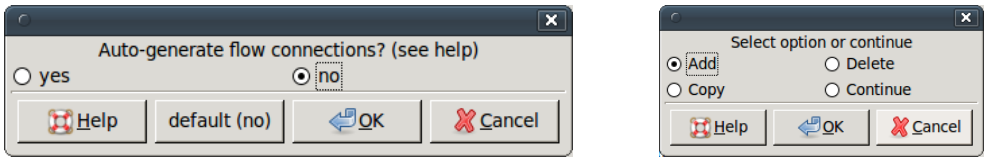


Figure 45: Network flow connections

Connections > + add/delete/copy

Select option or continue Add

First (+ve) node: Currently NONE

select the first node (e.g. ***Z0_int***)

First (-ve) node: Currently NONE

select the second (e.g. ***ext_north***)

Height of +ve linkage point relative to node Z0_int 0

Height of -ve linkage point relative to node ext_north 0

Linking component: (currently NONE)

win_open See fig. 46.

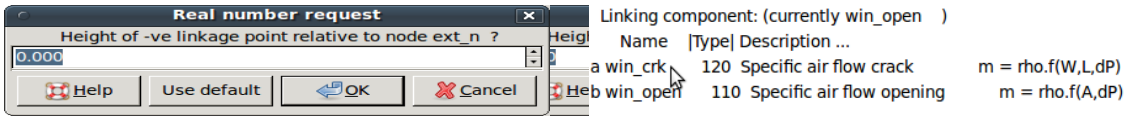

Real number request
Height of -ve linkage point relative to node ext_n ?
0.000
Help
Use default
OK
Cancel
Linking component: (currently win_open)
Name |Type| Description ...
a win_crk 120 Specific air flow crack m = rho.f(W,L,dP)
b win_open 110 Specific air flow opening m = rho.f(A,dP)

Figure 46: Network flow connection int_zo to ext_north via win_open

Repeat the process for the connection of ***Z0_int*** to ***ext_north*** via ***win_crk*** See fig. 47

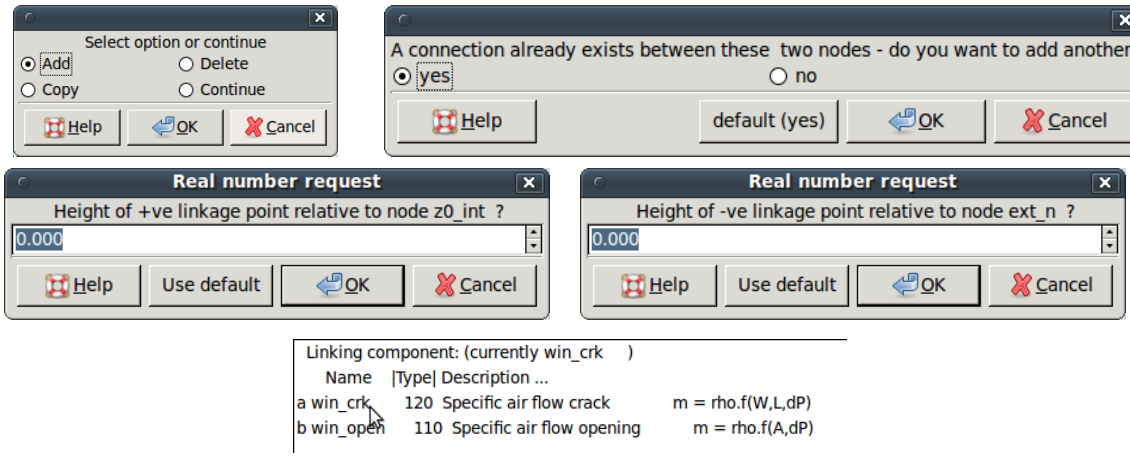


Figure 47: Network flow connection int_zo to ext_north via win_crk

Do a repeated connection between ***Z0_int*** and ***ext_south*** via ***win_open*** and ***Z0_int*** and ***ext_south*** now via the ***win_crk*** component.

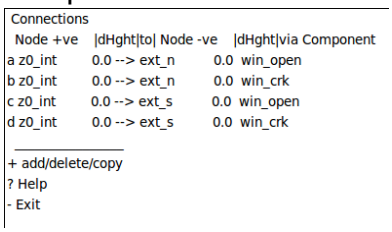

Connections
Node +ve |dHght|to| Node -ve |dHght|via Component
a z0_int 0.0 --> ext_n 0.0 win_open
b z0_int 0.0 --> ext_n 0.0 win_crk
c z0_int 0.0 --> ext_s 0.0 win_open
d z0_int 0.0 --> ext_s 0.0 win_crk
+ add/delete/copy
? Help
- Exit

Figure 48: Network flow connections.

Don't forget to ! `Save network`

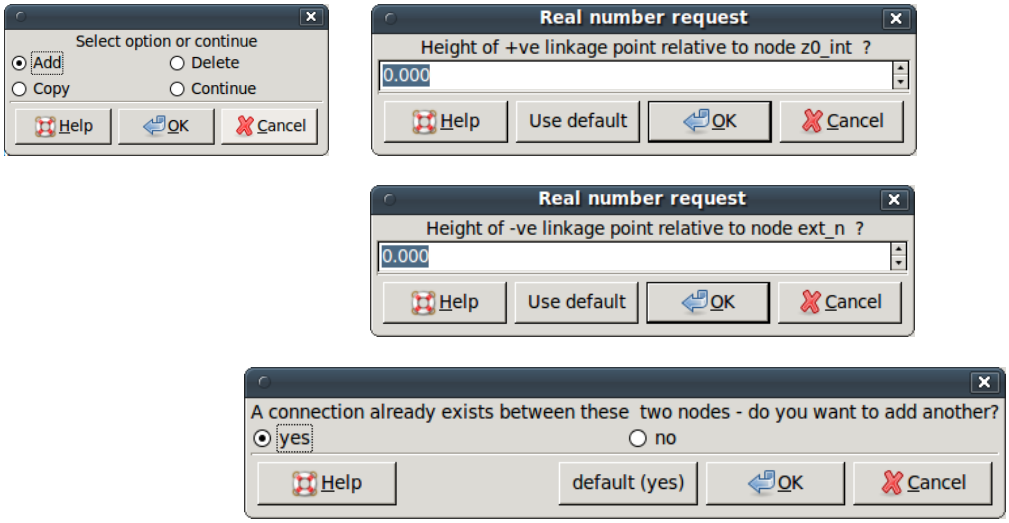


Figure 49: Network flow connection int_zo to ext_north via win_open

14.1. Natural Ventilated Zone - Control for air flow network by opening the windows

Having previous defined you fluid flow network with nodes, components and connections (**nets/NV.afn**) You will now define a control for that win_open component.

To Create a control for that ***win_open*** component

Model_Management>> m browse/edit/simulate >> Browse/Edit/Simulate >> (Controls)> l network flow

Control file? ../ctl/nv.ctl Ok

Controls> + add/delete/copy

Options: add loop

Nº vent/hydronic control day types (currently 0) weekday/saturday/sunday

How many periods in day type 1 (default is 1 period free floating) 3 See fig.50.

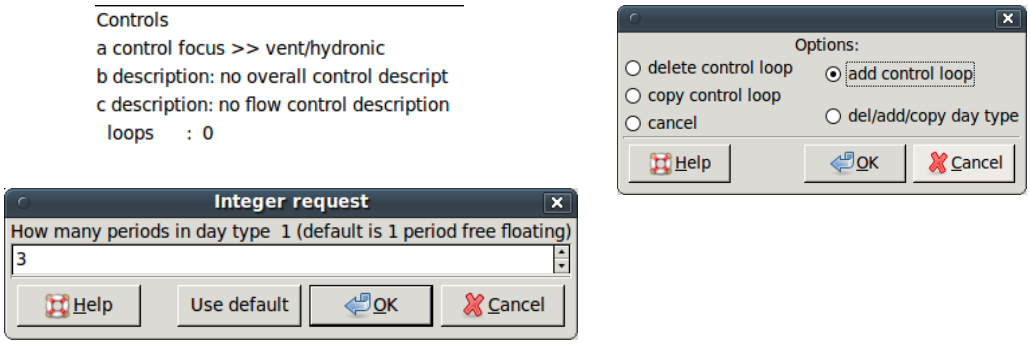


Figure 50: Network flow control.

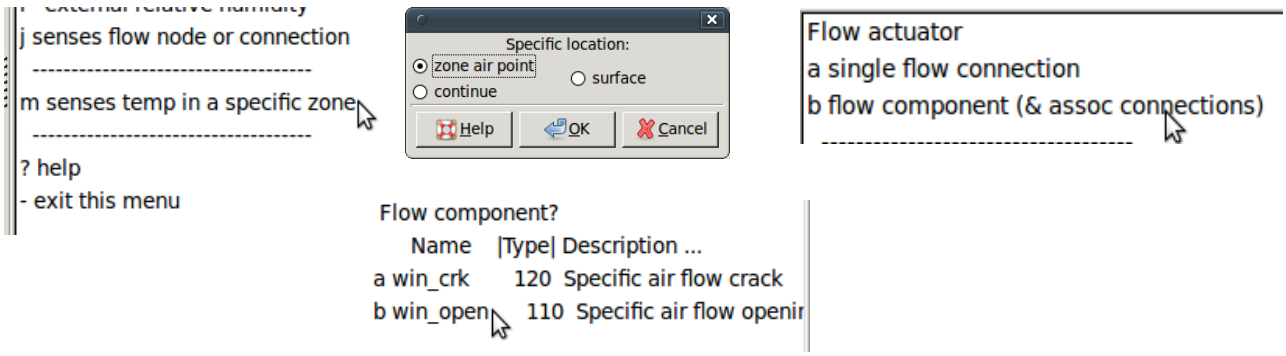


Figure 51: Network flow actuator.

Under Controls select the loop > Editing options> a sensor details

Flow sensor> m senses temp in a specific zone

select zone: z0

specific location> zone air point

Flow actuator> b flow component (&assoc connections)

Flow component> b win_open

See fig 51.

Editing options> c period of validity set for one year

Editing options> d period data

Control periods

Basically you will want the window to open during occupancy times when the inside temperature is above 24°C. Periods when the window is closed are set with a temperature setpoint unrealistic, say above 100°C.

Select one of the periods and in ***available laws> a on/off***

Period start time 0

On/Off setpoint, action (1=On above a setpoint, -1=On below) and fraction on: 100 1 0

The fraction of capacity (area, width or flow rate) accepts values for areas between 0.0 and 1.0 and for door width between 0.1 and 1.0.

Select the second period with the same law on/off, starting time at 9 and with a law setpoint and action set to 24 and 1 with fraction 1.

The last period will start at 18 with a law setpoint and action set to 100 and 1 and 0.

See fig. 52.

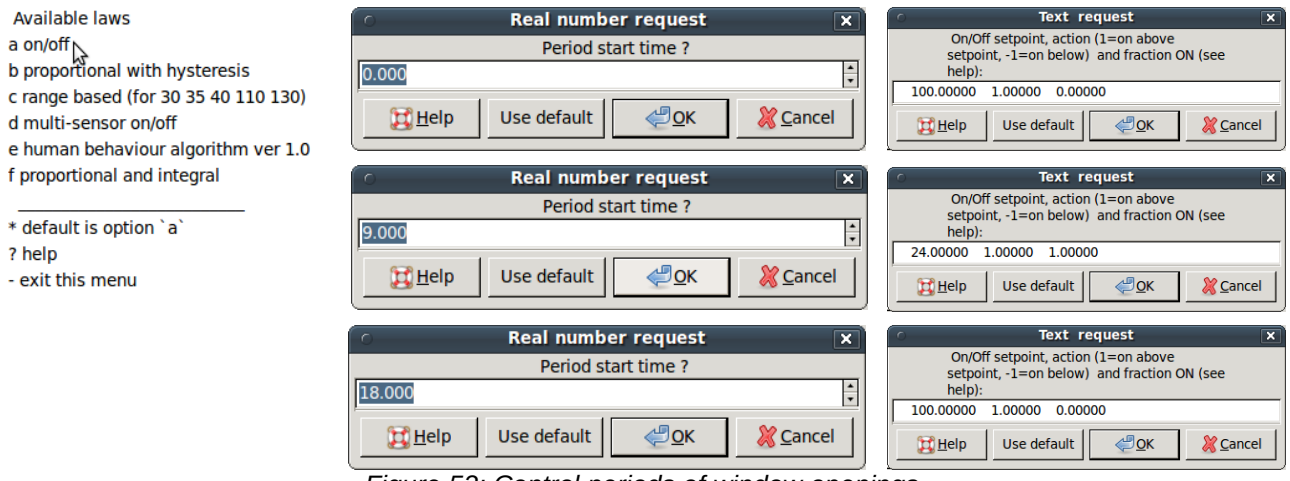


Figure 52: Control periods of window openings.

NOTE: Number of items for on/off controller = 2 1st is setpoint, 2nd is action index 1=direct, -1=inverse Where direct is ON above set point and inverse is ON below setpoint.

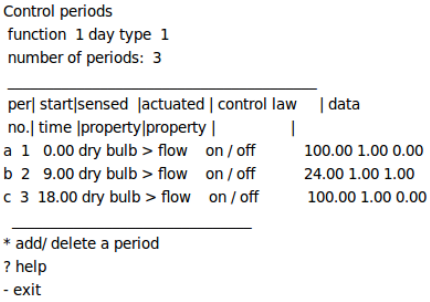

Control periods
function 1 day type 1
number of periods: 3
per| start|sensed |actuated | control law | data
no.| time |property|property | |
a 1 0.00 dry bulb > flow on / off 100.00 1.00 0.00
b 2 9.00 dry bulb > flow on / off 24.00 1.00 1.00
c 3 18.00 dry bulb > flow on / off 100.00 1.00 0.00
* add/ delete a period
? help
- exit

Figure 53: Control to simulate periods when windows are open during weekdays.

Check that your day type 2 (saturday) and 3 (sunday) have the windows closed all the time. Set one period starting at 0 with an on/off control set to 100 (setpoint) 1 (above threshold) 0 (fraction open).

Create a second control with one one period, actuating on the window_crk set up to be always fully open. See fig. 54.

See Annex 7 for details of a control file.

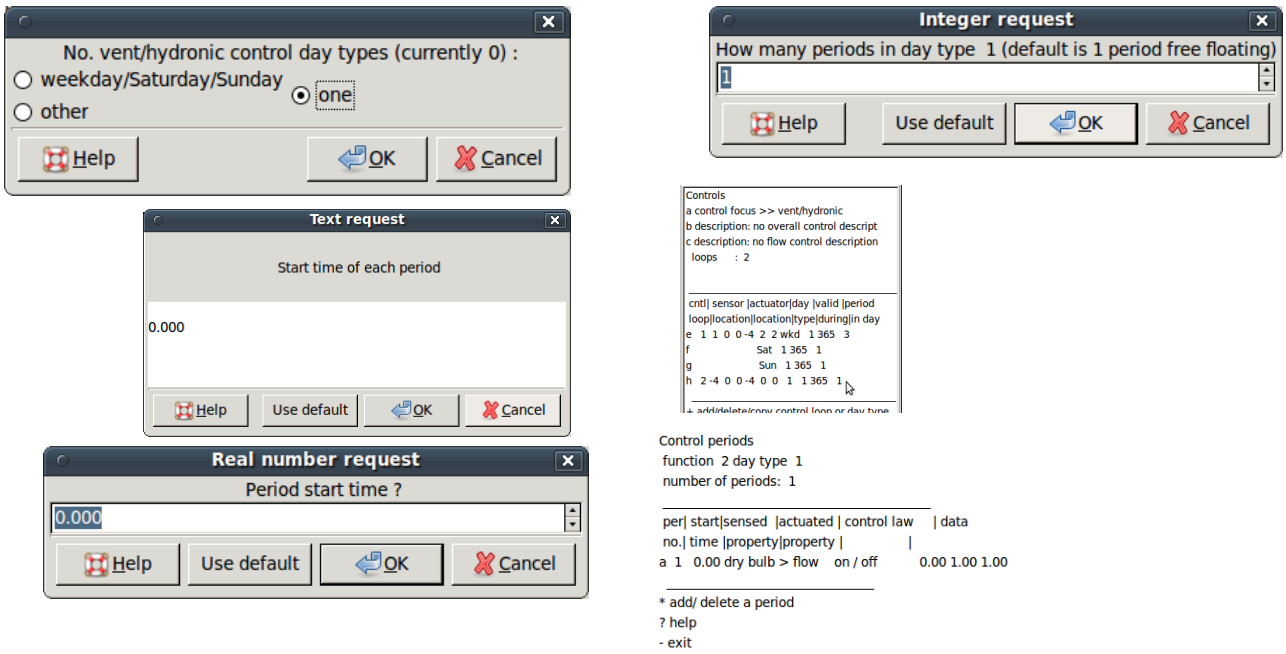


Figure 54: Control to simulate cracks permanently open to allow for fresh air.

Don't forget to `Controls> save control data`

15 RESULTS

15.1 Text description

Model Management>> m browse/edit/simulate >> Browse/Edit/Simulate> r results & QA reporting> Model reports> QA report

zone list> * all items

QA report to: text file

Export file name: AC_contents.txt

See Annex 3.

15.2 Graphs

In the module ESP-r Results Analysis

results analysis> 3 Define output period

Start day-of-month, month & time: beginning of period in study

End day-of-month, month & time: end of period in study

Output time-step increment ? 1

results analysis> *4 Select zones* > 'Zone in study'

See fig.55.

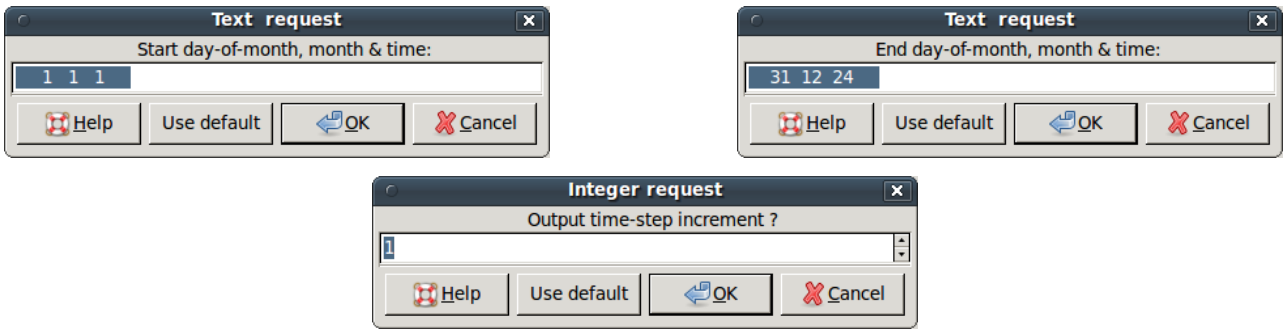


Figure 55: Set Output period (default is the run of the simulation) and time step for viewing results.

results analysis> a Graphs

Graph facilities> a Time:var graph

Time series plot> a Climate > a Ambient temperature; b Temperatures> a zone db T (or any other); f Zone flux> a Infiltration (from outside); ! Draw graph

In the graphic feedback window select the button *capture > options: user define area > file*: your path to the directory results. Select the window to be saved with your mouse.

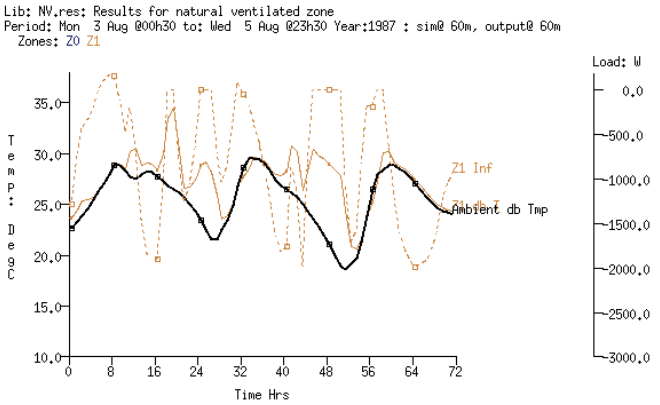

Lib: NV.res: Results for natural ventilated zone
Period: Mon 3 Aug @00h30 to: Wed 5 Aug @23h30 Year:1987 : sim@ 60m, output@ 60m
Zones: Z0 Z1
Load: W
Temp: Deg C
Z1 Inf
Ambient db Tmp
Time Hrs

Figure 56: Plot of zone dry bulb temperature, ambient temperature and infiltration load for the days 3rd to 5th August

Graph facilities> d Frequency histogram> b Temperatures> a Zone db T

Use default bin set-up:Yes

Frequency distribution for the hours distributed in the periods set of temperature or *cumulative freq. Dist.* for a cumulative bar graph of the hours in that period.

NOTE: for the AC scenario the period in study should be a year and for the NV scenario the week period defined in the summer.

You can define the range of the x axis by not using the default bin set_up and defining the minimum and maximum parameter values and the number of intervals.

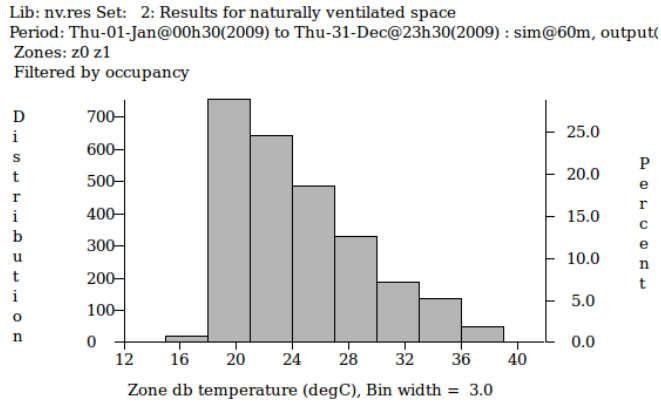

Lib: nv.res Set: 2: Results for naturally ventilated space
Period: Thu-01-Jan@00h30(2009) to Thu-31-Dec@23h30(2009) : sim@60m, output(
Zones: z0 z1
Filtered by occupancy
Distribution
Percent
Zone db temperature (degC), Bin width = 3.0

Figure 57: frequency distribution of hours when the zone dry bulb temperature is in a specific range

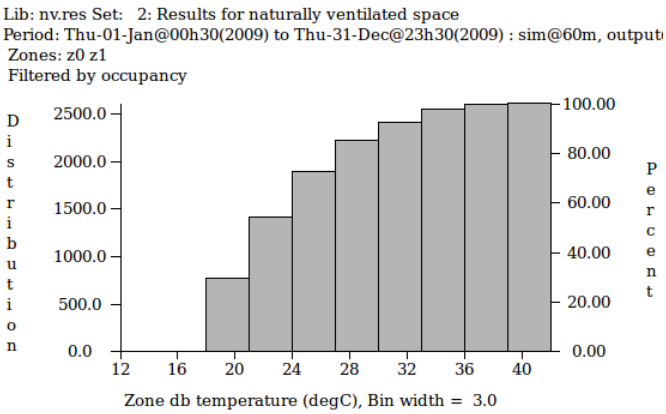


Figure 58: Cumulative distribution of hours when the zone dry bulb temperature is in a specific range

15.3 Nº of hours above or below a certain setpoint

results analysis> d Enquire about> c hours above a value> b Temperatures> a Zone db T

Test point value? 20

See Annex 4.

15.4 Energy consumption and nº of hours required

results analysis> d Enquire about> f energy delivered

or

results analysis> *d Enquire about> h zone energy balance*

Energy balance options: integrated over time

Zone energy balance (grouped by): plant status to see the casual energy breakdown for the heating, cooling and off period.

Zone energy balance (grouped by): gain/loss to see the casual energy breakdown in terms of gain and losses

See Annex 5.

16 Bibliography

- J. A. Clarke *Energy Simulation in Building Design* Butterworth Heinemann, Oxford et alibi, 2nd edition (2001)
- Jon William Hand The ESP-r Cookbook – Strategies for Deploying virtual Representations of the Build Environment, Energy Systems Research Unit, Department of Mechanical Engineering, University of Strathclyde, Glasgow, UK, 4 Set. 2008
- University of Strathclyde, Energy Systems Research Unit, ESRU Manual U00/1, *The ESP-r System for Building Energy Simulation User Guide Version 9 Series*, Glasgow, October 2000
- University of Strathclyde, Energy Systems Research Unit, ESRU report, *Data Model Summary ESP-r Version 9 series*, Glasgow, December 2001
- Consult the site www.esru.strath.ac.uk for tutorials, user manual, glossary and to browse the models provided.
- LEARNIX is a LINUX distribution that runs entirely off the CD-ROM, without the need to install into the hard disk. Data can be saved to a USB storage device or to an existing DOS partition. LEARNIX has been customised to include the building simulation that is taught in the LEARN MSc courses, namely ESP-r and RADIANCE. You can download your copy from the following address: http://luminance.londonmet.ac.uk/learnix You will also find links to other documents which might be of interest to you and tells you how to get help using LEARNIX.

ANNEX 1

MATERIALS DATABASE
ESP-r version series 10.3

Primitive	Identification	Condutivity (W/m° C)	Density (kg/m^3)	Specific Heat (J/kg° C)	IR emissivity	Solar absorptivity	Diffuse resistance
	1 Brick						
1	Paviour brick	0.96	2000	840	0.93	0.70	12
2	Breeze block	0.44	1500	650	0.90	0.65	15
3	Inner leaf brick	0.62	1800	840	0.93	0.70	29
4	Outer leaf brick	0.96	2000	650	0.90	0.93	25
5	Vermiculite insulating	0.27	700	840	0.90	0.65	12
	2 Concrete						
21	Light mix	0.38	1200	653	0.90	0.65	6
22	Aerated block	0.24	750	1000	0.90	0.65	10
23	Aerated concrete	0.16	500	840	0.90	0.65	13
24	Refractory insulating	0.25	10	837	0.90	0.65	12
25	Vermiculite aggregrate	0.17	450	837	0.90	0.65	12
26	No fines concrete	0.96	1800	840	0.90	0.65	18
27	Foamed slag concrete	0.25	1040	960	0.90	0.65	8
28	Block inner (3% mc)	0.51	1400	1000	0.90	0.65	10
29	Foamed inner block(3%mc	0.16	600	1000	0.90	0.65	6
30	Foamed outer block(5%mc	0.17	600	1000	0.90	0.65	8
31	Glass reinforced	0.90	1950	840	0.90	0.65	18
32	Heavy mix concrete	1.40	2100	653	0.90	0.65	19
	3 Metal						
41	Copper	200.00	8900	418	0.72	0.65	19200
42	Steel	50.00	7800	502	0.12	0.20	19200
43	Aluminium	210.00	2700	880	0.22	0.20	19200
	4 Wood						
61	Block (wood)	0.16	800	2093	0.90	0.65	11
62	Hardboard(medium)	0.08	600	2000	0.91	0.70	110
63	Hardboard(standard)	0.13	900	2000	0.91	0.70	140
64	Fir (20% mc)	0.14	419	2720	0.90	0.65	12
65	Flooring	0.14	600	1210	0.91	0.65	14
66	Cork board	0.04	160	1888	0.90	0.60	14
67	Chipboard	0.15	800	2093	0.91	0.65	96
68	Weatherboard	0.14	650	2000	0.91	0.65	100
69	Oak (radial)	0.19	700	2390	0.90	0.65	12
70	Plywood	0.15	560	2500	0.90	0.65	576
71	Softwood	0.13	630	2760	0.90	0.65	12
72	Plywood	0.15	700	1420	0.90	0.65	576
73	Softboard	0.56	350	1000	0.90	0.65	13
	5 Stone						
81	Sandstone	1.83	2200	712	0.90	0.60	29
82	Red granite	2.90	2650	900	0.90	0.55	77
83	White marble	2.00	2500	880	0.90	0.46	38
84	Limestone	1.50	2180	720	0.90	0.60	29
85	Slate	2.00	2700	753	0.90	0.60	48
86	Gravel	0.36	1840	840	0.90	0.60	2
87	Chippings	0.96	1800	1000	0.90	0.60	2

	6 Plaster						
101	Dense plaster	0.50	1300	1000	0.91	0.50	11
102	Light plaster	0.16	600	1000	0.91	0.50	8
103	Perlite plasterboard	0.18	800	837	0.91	0.60	9
104	Gypsum plaster	0.42	1200	837	0.91	0.50	11
105	Perlite plaster	0.08	400	837	0.91	0.50	11
106	Vermiculite plaster	0.20	720	837	0.91	0.50	11
107	Gypsum plasterboard	0.19	950	840	0.91	0.50	11
	7 Screeds and renders						
121	Lightweight concrete	0.41	1200	840	0.90	0.80	30
122	Cast concrete screed	1.28	2100	1007	0.90	0.65	44
123	Granolithic screed	0.87	2085	837	0.90	0.65	35
124	Cement screed	1.40	2100	650	0.91	0.65	19
125	White dry render	0.50	1300	1000	0.91	0.50	19
126	Rendering (1% mc)	1.13	1431	1000	0.91	0.50	19
127	Rendering (8% mc)	0.79	1329	1000	0.91	0.50	19
	8 Tiles						
141	Clay tile	0.85	1900	837	0.90	0.60	52
142	Concrete tile	1.10	2100	837	0.90	0.65	20
143	Slate	2.00	2700	753	0.95	0.85	48
144	Plastic tile	0.50	1050	837	0.90	0.40	1000
145	Rubber tile	0.30	1600	2000	0.94	0.82	1000
146	Cork tile	0.08	530	1800	0.90	0.60	58
147	Asphalt/asbestos	0.55	1900	837	0.90	0.70	150
148	P.V.C./asbestos	0.85	2000	837	0.90	0.60	1000
149	Tile bedding	1.40	2100	650	0.90	0.60	25
150	Ceiling (mineral)	0.03	290	2000	0.90	0.60	8
151	Ceiling (plaster)	0.38	1120	840	0.90	0.60	12
	9 Asphalt and bitumen						
161	Bitumen felt	0.50	1700	1000	0.90	0.90	1000
162	Roofing felt	0.19	960	837	0.90	0.90	15
163	Asphalt mastic roofing	1.15	2325	837	0.90	0.90	19200
164	Asphalt	1.20	2300	1700	0.90	0.90	1900
165	Bitumen composit (floor)	0.85	2400	1000	0.90	0.90	1500
166	Bitumen impregnt`d paper	0.06	1090	1000	0.90	0.90	3000
167	Asphalt reflective coat	1.20	2300	1700	0.30	0.30	1900
	10 Asbestos						
181	Asbestos cement	0.36	1500	1000	0.90	0.60	300
182	Cement sheet	0.36	700	1050	0.96	0.60	150
183	Asbestos sheet	0.16	2500	1050	0.90	0.96	300
184	Asbestos insulation	0.16	577	840	0.90	0.60	3
	11 Insulation materials (1)						
201	Fibreboard	0.06	300	1000	0.90	0.50	13
202	Woodwool	0.10	500	1000	0.90	0.50	5
203	UF foam	0.03	30	1764	0.90	0.50	5
204	Thermalite	0.19	753	837	0.90	0.70	10
205	Polyurethane foam board	0.03	30	837	0.90	0.50	90
206	Siporex	0.12	550	1004	0.90	0.40	60
207	PVC	0.16	1379	1004	0.90	0.60	70
208	Hard rubber	0.15	1200	1000	0.94	0.92	500
209	Cratherm board	0.05	176	837	0.90	0.50	20
210	Silicon	0.18	700	1004	0.90	0.60	10

211	Glasswool	0.04	250	840	0.90	0.30	4
212	Roof insulation board	0.19	960	950	0.90	0.55	15
213	Felt sheathing	0.19	960	950	0.90	0.90	15
214	EPS	0.03	25	1000	0.90	0.30	67
215	Expanded PVC	0.04	100	750	0.90	0.60	40
216	Mineral fibre	0.04	105	1800	0.90	0.60	1
217	Cork insulation	0.04	105	1800	0.90	0.60	15
218	Straw thatch	0.07	240	180	0.90	0.50	3
219	Thermalite turbo block	0.11	480	1050	0.90	0.65	10
	12 Carpet						
221	Wilton	0.06	186	1360	0.90	0.60	10
222	Simulated sheeps wool	0.06	198	1360	0.90	0.60	10
223	Wool felt underlay	0.04	160	1360	0.90	0.65	10
224	Cellular rubber underlay	0.10	400	1360	0.90	0.65	1000
225	Synthetic carpet	0.06	160	2500	0.90	0.65	10
	13 Glass						
241	Glass block	0.70	3500	837	0.83	0.05	19200
242	Plate glass	0.76	2710	837	0.83	0.05	19200
243	4mm clear float	1.05	2500	750	0.83	0.05	19200
244	6mm Antisun	1.05	2500	750	0.59	0.06	19200
	14 Earth						
261	Infusorial (9% mc)	0.09	480	180	0.90	0.85	5
262	Gravel based	0.52	2050	184	0.90	0.85	2
263	Common earch	1.28	1460	879	0.90	0.85	5
	15 Insulation materials (2)						
281	Glass Fibre Quilt	0.04	12	840	0.90	0.65	30

ANNEX 2

CONSTRUCTIONS DATABASE

ESP-r version series 10.3

In the MLC database:

usr/esru/esp-r/databases/multicon.db1

Details of transparent construction: d_glz with DCF7671_06nb optics.

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R m^2K/W	|Descr
Ext	242	0.0060	0.760	2710.	837.	0.83	0.05	19200.	0.01	Plate glass
2	0	0.0120	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	242	0.0060	0.760	2710.	837.	0.83	0.05	19200.	0.01	Plate glass

Standardised U value = 2.75

Clear float 76/71, 6mm, no blind: with id of: DCF7671_06nb

with 3 layers [including air gaps] and visible trn: 0.76

Direct transmission @ 0, 40, 55, 70, 80 deg

0.611 0.583 0.534 0.384 0.170

Layer	|absorption @	0,	40,	55,	70,	80 deg
1		0.157	0.172	0.185	0.201	0.202
2		0.001	0.002	0.003	0.004	0.005
3		0.117	0.124	0.127	0.112	0.077

Details of opaque composite: extern_wall

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R m^2K/W	|Descr
Ext	4	0.1000	0.960	2000.	650.	0.90	0.93	25.	0.10	Outer leaf brick
2	211	0.0750	0.040	250.	840.	0.90	0.30	4.	1.88	Glasswool
3	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	2	0.1000	0.440	1500.	650.	0.90	0.65	15.	0.23	Breeze block

Standardised U value = 0.39

Details of opaque composite: roof_1

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R m^2K/W	|Descr

Ext	162	0.0120	0.190	960.	837.	0.90	0.90	15.	0.06	Roofing felt
2	21	0.0500	0.380	1200.	653.	0.90	0.65	6.	0.13	Light mix
3	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	151	0.0080	0.380	1120.	840.	0.90	0.60	12.	0.02	Ceiling (plaster)
Standardised U value =			1.77							

Details of opaque composite: floor_1

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
Ext	263	0.1000	1.280	1460.	879.	0.90	0.85	5.	0.08	Common earch
2	82	0.1000	2.900	2650.	900.	0.90	0.55	77.	0.03	Red granite
3	32	0.0500	1.400	2100.	653.	0.90	0.65	19.	0.04	Heavy mix concrete
Int	124	0.0500	1.400	2100.	650.	0.91	0.65	19.	0.04	Cement screed
Standardised U value =			2.76							

Details of opaque composite: intern_wall

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
Ext	2	0.1500	0.440	1500.	650.	0.90	0.65	15.	0.34	Breeze block
Int	103	0.0120	0.180	800.	837.	0.91	0.60	9.	0.07	Perlite plasterboard
Standardised U value =			1.71							

Details of opaque composite: door

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
1	69	0.0250	0.190	700.	2390.	0.90	0.65	12.	0.13	Oak (radial)
Standardised U value =			3.23							

Details of opaque composite: grnd_floor

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
Ext	263	0.2500	1.280	1460.	879.	0.90	0.85	5.	0.20	Common earch
2	262	0.1500	0.520	2050.	184.	0.90	0.85	2.	0.29	Gravel based
3	32	0.1500	1.400	2100.	653.	0.90	0.65	19.	0.11	Heavy mix concrete
4	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17

5	67	0.0190	0.150	800.	2093.	0.91	0.65	96.	0.13	Chipboard
Int	221	0.0060	0.060	186.	1360.	0.90	0.60	10.	0.10	Wilton

Standardised U value = 0.86

Details of transparent construction: dbl_glz with DCF7671_06nb optics.

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
Ext	242	0.0060	0.760	2710.	837.	0.83	0.05	19200.	0.01	Plate glass
2	0	0.0120	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	242	0.0060	0.760	2710.	837.	0.83	0.05	19200.	0.01	Plate glass

Standardised U value = 2.75

Clear float 76/71, 6mm, no blind: with id of: DCF7671_06nb

with 3 layers [including air gaps] and visible trn: 0.76

Direct transmission @ 0, 40, 55, 70, 80 deg

0.611 0.583 0.534 0.384 0.170

Layer	|absorption @	0,	40,	55,	70,	80 deg
1		0.157	0.172	0.185	0.201	0.202
2		0.001	0.002	0.003	0.004	0.005
3		0.117	0.124	0.127	0.112	0.077

Details of opaque composite: roof

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
Ext	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium
2	0	0.0250	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
3	281	0.0800	0.040	12.	840.	0.90	0.65	30.	2.00	Glass Fibre Quilt
Int	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium

Standardised U value = 0.43

Details of opaque composite: susp_ceil

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R $\|m^2K/W$	|Descr
1	104	0.0130	0.420	1200.	837.	0.91	0.50	11.	0.03	Gypsum plaster

Standardised U value = 4.79

Details of opaque composite: entry_floor

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m²K/W	|Descr
Ext	263	0.2500	1.280	1460.	879.	0.90	0.85	5.	0.20	Common earch
2	262	0.1500	0.520	2050.	184.	0.90	0.85	2.	0.29	Gravel based
3	32	0.1500	1.400	2100.	653.	0.90	0.65	19.	0.11	Heavy mix concrete
Int	83	0.0240	2.000	2500.	880.	0.90	0.46	38.	0.01	White marble

Standardised U value = 1.28

Details of opaque composite: int_doors

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m²K/W	|Descr
1	69	0.0250	0.190	700.	2390.	0.90	0.65	12.	0.13	Oak (radial)

Standardised U value = 3.23

Details of opaque composite: first_compos

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m²K/W	|Descr
Ext	43	0.0020	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium
Int	69	0.0250	0.190	700.	2390.	0.90	0.65	12.	0.13	Oak (radial)

Standardised U value = 3.23

Details of opaque composite: ext_wall

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m²K/W	|Descr
Ext	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium
2	0	0.0250	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
3	281	0.0800	0.040	12.	840.	0.90	0.65	30.	2.00	Glass Fibre Quilt
4	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium
5	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	104	0.0130	0.420	1200.	837.	0.91	0.50	11.	0.03	Gypsum plaster

Standardised U value = 0.39

Details of opaque composite: partition

Layer	|Prim	|Thick	|Conduc-	|Density	|Specif	|IR	|Solr	|Diffu	|R	|Descr

		db		(m)		tivity				heat		emis		abs		resis		m²K/W				
Ext	104	0.0130	0.420	1200.	837.	0.91	0.50	11.	0.03	Gypsum										
plaster																				
2	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air	0.17	0.17								
0.17																				
3	28	0.1000	0.510	1400.	1000.	0.90	0.65	10.	0.20	Block inner (3%										
mc)																				
4	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air	0.17	0.17								
0.17																				
Int	104	0.0130	0.420	1200.	837.	0.91	0.50	11.	0.03	Gypsum										
plaster																				
Standardised U value =			1.29																	

Details of opaque composite: susp_floor

Layer		Prim		Thick		Conduc-		Density		Specif		IR		Solr		Diffu		R		Descr		
		db		(m)		tivity				heat		emis		abs		resis		m²K/W				
Ext	221	0.0060	0.060	186.	1360.	0.90	0.60	10.	0.10	Wilton										
2	67	0.0190	0.150	800.	2093.	0.91	0.65	96.	0.13	Chipboard										
3	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air	0.17	0.17								
0.17																				
4	32	0.1400	1.400	2100.	653.	0.90	0.65	19.	0.10	Heavy	mix									
concrete																				
Int	42	0.0040	50.000	7800.	502.	0.12	0.20	19200.	0.00	Steel										
Standardised U value =			1.48																	

Details of opaque composite: susp_flr_re

Layer		Prim		Thick		Conduc-		Density		Specif		IR		Solr		Diffu		R		Descr		
		db		(m)		tivity				heat		emis		abs		resis		m²K/W				
Ext	42	0.0040	50.000	7800.	502.	0.12	0.20	19200.	0.00	Steel										
2	32	0.1400	1.400	2100.	653.	0.90	0.65	19.	0.10	Heavy	mix									
concrete																				
3	0	0.0500	0.000	0.	0.	0.99	0.99	1.	0.17	air	0.17	0.17								
0.17																				
4	67	0.0190	0.150	800.	2093.	0.91	0.65	96.	0.13	Chipboard										
Int	221	0.0060	0.060	186.	1360.	0.90	0.60	10.	0.10	Wilton										
Standardised U value =			1.48																	

Details of opaque composite: dummy_pnls

Layer		Prim		Thick		Conduc-		Density		Specif		IR		Solr		Diffu		R		Descr		
		db		(m)		tivity				heat		emis		abs		resis		m²K/W				
Ext	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium										
2	281	0.0800	0.040	12.	840.	0.90	0.65	30.	2.00	Glass	Fibre									
Quilt																				

Int	43	0.0030	210.000	2700.	880.	0.22	0.20	19200.	0.00	Aluminium

Standardised U value = 0.46

Details of opaque composite: mass_part

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m^2K/W	|Descr
1	28	0.2400	0.510	1400.	1000.	0.90	0.65	10.	0.47	Block inner (3% mc)

Standardised U value = 1.54

Details of opaque composite: int_part

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m^2K/W	|Descr
Ext	103	0.0120	0.180	800.	837.	0.91	0.60	9.	0.07	Perlite plasterboard
2	0	0.0250	0.000	0.	0.	0.99	0.99	1.	0.17	air 0.17 0.17 0.17
Int	103	0.0120	0.180	800.	837.	0.91	0.60	9.	0.07	Perlite plasterboard

Standardised U value = 2.08

Details of opaque composite: ceiling

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m^2K/W	|Descr
Ext	211	0.1000	0.040	250.	840.	0.90	0.30	4.	2.50	Glasswool
Int	150	0.0100	0.030	290.	2000.	0.90	0.60	8.	0.33	Ceiling (mineral)

Standardised U value = 0.33

Details of opaque composite: ceiling_rev

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m^2K/W	|Descr
Ext	150	0.0100	0.030	290.	2000.	0.90	0.60	8.	0.33	Ceiling (mineral)
Int	211	0.1000	0.040	250.	840.	0.90	0.30	4.	2.50	Glasswool

Standardised U value = 0.33

Details of opaque composite: roof_2

Layer	|Prim |db	|Thick |(m)	|Conduc- |tivity	|Density |	|Specif |heat	|IR |emis	|Solr |abs	|Diffu |resis	|R |m^2K/W	|Descr

Ext	141	0.0150	0.850	1900.	837.	0.90	0.60	52.	0.02	Clay tile
2	162	0.0050	0.190	960.	837.	0.90	0.90	15.	0.03	Roofing felt
Int	72	0.0120	0.150	700.	1420.	0.90	0.65	576.	0.08	Plywood

Standardised U value = 3.31

U value assumes: external wall with Rso = 0.055m**2deg.C/W

and Rsi = 0.123m**2deg.C/W

ANNEX 3

```
cfg: ac.cfg
project: air conditioning building with 2 zones
print date: Fri Nov 19 03:11:07 2004

ID Zone         Volume|          Surface
   Name         m^3   | No. Opaque  Transp  ~Floor
 1 grd            32.4   9    57.8     4.0    12.0  grd is a room on ground floor
 2 1st            32.4   9    57.8     4.0    12.0  1st floor air conditioning
   all            65.   18    116.      8.     24.

_____________________________________________________________
 Control description: proj cntrl


 Zones control: no descrip : 1 functions.

 The sensor for function  1 senses the temperature of the current zone.
 The actuator for function  1 is air point of the current zone
 The function day types are Weekdays, Saturdays & Sundays

 Weekday control is valid Sat  1 Jan to Sun 31 Dec, 2000 with  4 periods.
 Per|Start|Sensing  |Actuating  | Control law       | Data
   1  0.00 db temp   > flux      free floating
    2  8.00 db temp    > flux       basic control        2000.0 0.0 2000.0 0.0 20.0 25.0
0.0
   3  9.00 db temp    > flux       basic control        3000.0 0.0 3000.0 0.0 20.0 25.0
0.0
   4 18.00 db temp   > flux      free floating

 Saturday control is valid Sat  1 Jan to Sun 31 Dec, 2000 with  1 periods.
 Per|Start|Sensing  |Actuating  | Control law       | Data
   1  0.00 db temp   > flux      free floating

 Sunday control is valid Sat  1 Jan to Sun 31 Dec, 2000 with  1 periods.
 Per|Start|Sensing  |Actuating  | Control law       | Data
   1  0.00 db temp   > flux      free floating

 Zone to contol loop linkages:
 zone ( 1) grd          << control  1
 zone ( 2) 1st          << control  0

_____________________________________________________________

 Zone grd ( 1) is composed of 9 surfaces and 20 vertices.
 It encloses a volume of 32.40m^3 of space, with a total surface
 area of 61.80m^2 & approx floor area of 12.00m^2
 grd is a room on ground floor
 There is 49.80m2 of exposed surface area, 37.80m2 of which is vertical.
 Outside walls are 281.7 % of floor area & avg U of 0.000 & UA of 0.00
 Flat roof is 100.0 % of floor area & avg U of 0.332 & UA of 3.985
 Glazing is 33.33 % of floor & 10.58 % facade with avg U of 2.749 & UA of 11.00

 A summary of the surfaces in grd( 1) follows:

 Sur| Area  |Azim|Elev| surface    |geometry| construction |environment
    | m^2   |deg |deg | name       |type|loc| name         |other side
```

```
  1     8.80 180.   0. grd_south    OPAQ VERT extern_wall  ||< external
  2     8.10  90.   0. grd_west     OPAQ VERT extern_wall  ||< external
  3     8.80   0.   0. gnd_north    OPAQ VERT extern_wall  ||< external
  4     8.10 270.   0. grd_east     OPAQ VERT extern_wall  ||< external
  5    12.00   0.  90. gnd_cei      OPAQ CEIL ceiling      ||< external
  6    12.00   0. -90. grd_foor     OPAQ FLOR grnd_floor   ||< ground profile  1
  7     2.00 180.   0. s_w1         TRAN VERT d_glz        ||< external
  8     1.00 360.   0. grn_n_w1     TRAN VERT d_glz        ||< external
  9     1.00 360.   0. grd_n_w2     TRAN VERT d_glz        ||< external


 All surfaces will receive diffuse insolation.


 Description: nil_operations
 Control: infil & vent: zone T
 Lower/Middle/High temp setpoints:   20.00  26.00 100.00
                    Infil. ac/h m^3/s  Vent. ac/h m^3/s  from  data
 Lower range data     0.500  0.0045     0.000  0.0000    0     0.000
 Middle range data    0.500  0.0045     2.000  0.0180    0    20.000
 High range data      0.500  0.0045     5.000  0.0450    0    20.000

 Number of Weekday Sat Sun air change periods =  0  0  0


 Description : nil_operations
 Number of Weekday Sat Sun casual gains=  2  0  0
Day Gain Type     Period Sensible  Latent     Radiant    Convec
    No.  labl     Hours  Magn.(W)  Magn. (W)  Frac       Frac
Wkd  1 OccuptW    9 - 18     95.0     45.0       0.20       0.80
Wkd  2 LightsWm2 16 - 18     10.0      0.0       0.60       0.40

 ____________________________________________________________

 Zone 1st ( 2) is composed of 9 surfaces and 20 vertices.
 It encloses a volume of 32.40m^3 of space, with a total surface
 area of 61.80m^2 & approx floor area of 12.00m^2
 1st floor air conditioning
 There is 49.80m2 of exposed surface area, 37.80m2 of which is vertical.
 Outside walls are 281.7 % of floor area & avg U of 0.000 & UA of 0.00
 Flat roof is 100.0 % of floor area & avg U of 0.332 & UA of 3.985
 Glazing is 33.33 % of floor & 10.58 % facade with avg U of 2.749 & UA of 11.00

 A summary of the surfaces in 1st( 2) follows:

 Sur| Area  |Azim|Elev| surface    |geometry| construction |environment
    | m^2   |deg |deg | name       |type|loc| name         |other side
  1     8.80 180.   0. grd_south    OPAQ VERT extern_wall  ||< external
  2     8.10  90.   0. grd_west     OPAQ VERT extern_wall  ||< external
  3     8.80   0.   0. gnd_north    OPAQ VERT extern_wall  ||< external
  4     8.10 270.   0. grd_east     OPAQ VERT extern_wall  ||< external
  5    12.00   0.  90. gnd_cei      OPAQ CEIL ceiling      ||< external
  6    12.00   0. -90. grd_foor     OPAQ FLOR grnd_floor   ||< ground profile  1
  7     2.00 180.   0. s_w1         TRAN VERT d_glz        ||< external
  8     1.00   0.   0. grn_n_w1     TRAN VERT d_glz        ||< external
  9     1.00   0.   0. grd_n_w2     TRAN VERT d_glz        ||< external


 All surfaces will receive diffuse insolation.


 Description: nil_operations
```

```
Control: no control of air flow

Number of Weekday Sat Sun air change periods =  0  0  0


Description : nil_operations
Number of Weekday Sat Sun casual gains=  0  0  0

_____________________________________________________________

Project floor area is 24.00m2, wall area is 67.60m2, window area is 8.000m2.
Sloped roof area is 0.00m2, flat roof area is 24.00m2, skylight area is 0.00m2.
There is 99.60m2 of outside surface area, 75.60m2 of which is vertical.

Outside walls are 281.7 % of floor area & avg U of 0.000 & UA of 0.00
Flat roof is 100.0 % of floor area & avg U of 0.332 & UA of 7.970
Glazing is 33.33 % of floor & 10.58 % facade with avg U of 2.749 & UA of 21.99

_____________________________________________________________
Multi-layer constructions used:

Details of transparent construction: d_glz        with DCF7671_06nb optics.

Layer|Prim|Thick |Conduc-|Density|Specif|IR  |Solr|Diffu| R    |Descr
     |db  | (m)  |tivity |       |heat  |emis|abs |resis|m^2K/W
Ext   242 0.0060     0.760  2710.   837. 0.83 0.05 19200.  0.01 Plate glass
   2    0 0.0120     0.000     0.     0. 0.99 0.99     1.  0.17 air  0.17 0.17 0.17
Int   242 0.0060     0.760  2710.   837. 0.83 0.05 19200.  0.01 Plate glass
Standardised U value =    2.75

Clear float 76/71,     6mm, no blind: with id of: DCF7671_06nb
with 3 layers [including air gaps] and visible trn: 0.76
Direct transmission @ 0, 40, 55, 70, 80 deg
  0.611 0.583 0.534 0.384 0.170
Layer| absorption @ 0, 40, 55, 70, 80 deg
   1  0.157 0.172 0.185 0.201 0.202
   2  0.001 0.002 0.003 0.004 0.005
   3  0.117 0.124 0.127 0.112 0.077
Total area of d_glz is      8.00

Details of opaque construction: grnd_floor

Layer|Prim|Thick |Conduc-|Density|Specif|IR  |Solr|Diffu| R    |Descr
     |db  | (m)  |tivity |       |heat  |emis|abs |resis|m^2K/W
Ext   263 0.2500     1.280  1460.   879. 0.90 0.85     5.  0.20 Common_earth
   2  262 0.1500     0.520  2050.   184. 0.90 0.85     2.  0.29 Gravel based
   3   32 0.1500     1.400  2100.   653. 0.90 0.65    19.  0.11 Heavy mix concrete
   4    0 0.0500     0.000     0.     0. 0.99 0.99     1.  0.17 air  0.17 0.17 0.17
   5   67 0.0190     0.150   800.  2093. 0.91 0.65    96.  0.13 Chipboard
Int   221 0.0060     0.060   186.  1360. 0.90 0.60    10.  0.10 Wilton
Standardised U value =    0.86
Total area of grnd_floor is     24.00

Details of opaque construction: ceiling

Layer|Prim|Thick |Conduc-|Density|Specif|IR  |Solr|Diffu| R    |Descr
     |db  | (m)  |tivity |       |heat  |emis|abs |resis|m^2K/W
Ext   211 0.1000     0.040   250.   840. 0.90 0.30     4.  2.50 Glasswool
Int   150 0.0100     0.030   290.  2000. 0.90 0.60     8.  0.33 Ceiling (mineral)
Standardised U value =    0.33
Total area of ceiling is     24.00
```

ANNEX 4

```
Lib: nv.res                 Set:   1: Results for naturally ventilated zone
Period: Sat  1 Jan @00h30 to: Sun 31 Dec @23h30 Year:2000
Time steps: sim@ 60m, output@ 60m
Zone db temperature (degC)
Reporting number of hours above   26.00

 Description       Maximum                Minimum            Mean    No of hours     %
                    value   occurrence      value   occurrence      value    above   below
above
grd             29.40 12 Jul@17h30    11.07 10 Jan@09h30    20.67   52.00 2279.00   2.2
1st                 No data: probably due to filtering.

 Total number of hours greater than query point:     52.00  (  2.2%)
 Total number of hours less than or equal to query point:   2279.00  ( 97.8%)
```

ANNEX 5

Lib: ac.res: air conditioning building with 2 zones
Period: Sat 1 Jan @00h30 to: Sun 31 Dec @23h30 Year:2000 : sim@ 60m, output@ 60m

Zone total sensible and latent plant used (kWhrs)

Zone id	name	Sensible heating Energy (kWhrs)	No. of Hr rqd	Sensible cooling Energy (kWhrs)	No. of Hr rqd	Humidification Energy (kWhrs)	No. of Hr rqd	Dehumidification Energy (kWhrs)	No. of Hr rqd
1	grd	887.48	2022.0	-31.22	326.0	0.00	0.0	0.00	0.0
2	1st	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0
	All	887.48		-31.22		0.00		0.00	

Lib: ac.res: air conditioning building with 2 zones
Period: Sat 1 Jan @00h30 to: Sun 31 Dec @23h30 Year:2000 : sim@ 60m, output@ 60m

Causal energy breakdown (kWhrs) at air point for zone 1: grd

	Htg. period Gain	Loss	Clg. period Gain	Loss	OFF period Gain	Loss
|Infiltr	0.00	-114.33	0.00	0.00	0.00	-146.35
|Ventilat	0.00	0.00	0.00	0.00	0.00	-0.60
|UCOccupt	123.35	0.00	22.80	0.00	31.01	0.00
|UCLights	15.77	0.00	3.79	0.00	5.30	0.00
|UCEquipt	0.00	0.00	0.00	0.00	0.00	0.00
|O MLC ex	0.18	-748.75	6.19	-4.81	213.14	-32.56
|O MLC in	0.00	-66.97	0.18	-1.42	20.40	-11.94
|T MLC ex	1.62	-88.71	5.61	-0.86	10.35	-98.64
|T MLC in	0.00	0.00	0.00	0.00	0.00	0.00
|Plant	887.48	0.00	0.00	-31.22	0.00	0.00
Totals	1028.4	-1018.8	38.6	-38.3	280.2	-290.1

Causal energy breakdown (kWhrs) at air point for zone 2: 1st

	Htg. period Gain	Loss	Clg. period Gain	Loss	OFF period Gain	Loss
|Infiltr	0.00	0.00	0.00	0.00	0.00	0.00
|Ventilat	0.00	0.00	0.00	0.00	0.00	0.00
|UCOccupt	0.00	0.00	0.00	0.00	0.00	0.00
|UCLights	0.00	0.00	0.00	0.00	0.00	0.00
|UCEquipt	0.00	0.00	0.00	0.00	0.00	0.00
|O MLC ex	0.00	0.00	0.00	0.00	30.95	-15.78
|O MLC in	0.00	0.00	0.00	0.00	29.69	-5.14
|T MLC ex	0.00	0.00	0.00	0.00	7.06	-46.78
|T MLC in	0.00	0.00	0.00	0.00	0.00	0.00
No plant input/extract						
Totals	0.0	0.0	0.0	0.0	67.7	-67.7

Lib: ac.res: air conditioning building with 2 zones
Period: Sat 1 Jan @00h30 to: Sun 31 Dec @23h30 Year:2000 : sim@ 60m, output@ 60m

Causal energy breakdown (kWhrs) at air point for zone 1: grd

	Gain	Loss

```
Infiltration air load          0.001    -260.685
Ventilation air load           0.000      -0.601
Occupt casual gains          177.155       0.000
Lights casual gains           24.864       0.000
Equipt casual gains            0.000       0.000
Opaque MLC convec: ext       219.514    -786.117
Opaque MLC convec: int        20.576     -80.342
Transp MLC convec: ext        17.584    -188.216
Transp MLC convec: int         0.000       0.000
Convec portion of plant      887.484     -31.218
Totals                      1347.178   -1347.179

Causal energy breakdown (kWhrs) at air point for zone 2: 1st

                              Gain         Loss
Infiltration air load          0.000       0.000
Ventilation air load           0.000       0.000
Occupt casual gains            0.000       0.000
Lights casual gains            0.000       0.000
Equipt casual gains            0.000       0.000
Opaque MLC convec: ext        30.951     -15.779
Opaque MLC convec: int        29.685      -5.142
Transp MLC convec: ext         7.065     -46.780
Transp MLC convec: int         0.000       0.000
No plant input/extract
Totals                        67.701     -67.701
```

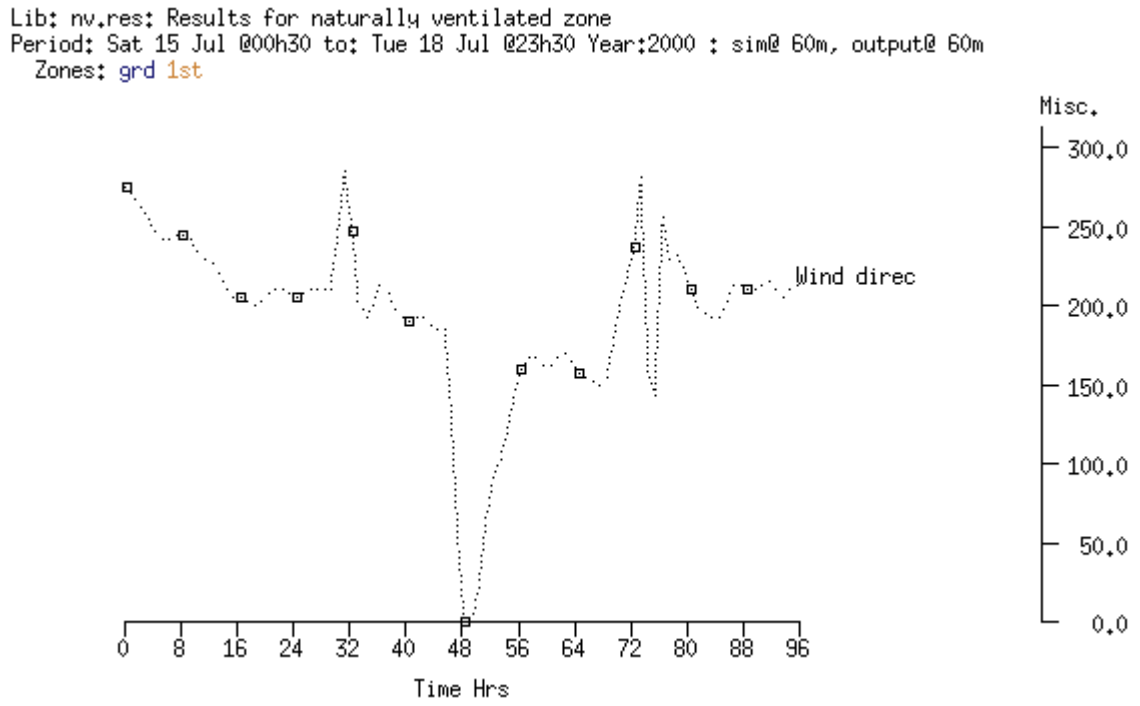


Figure 59: Wind direction from London weather file in 15th to 18th July 1967.

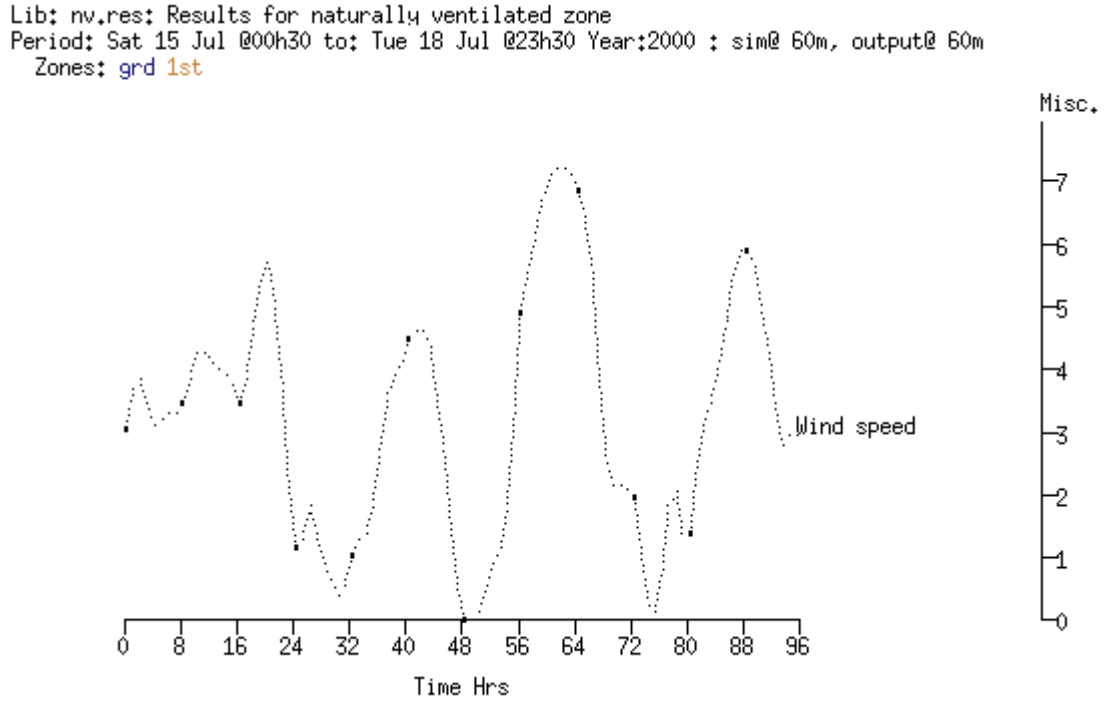


Figure 60: Wind speed from London weather file in 15th to 18th July 1967.

ANNEX 7

bbNV.ctl file

```
Naturally ventilated zone  # overall descr
* Building
no descrip  # bld descr
   1  # No. of functions
* Control function
# senses the temperature of the current zone.
    0    0    0    0  # sensor data
# actuates air point of the current zone
    0    0    0  # actuator data
    0 # No. day types
    1  365  # valid Sat  1 Jan - Sun 31 Dec
     3  # No. of periods in day
    0    2   0.000  # ctl type, law (free floating), start @
      0.  # No. of data items
    0    1   9.000  # ctl type, law (basic control), start @
      7.  # No. of data items
  3000.000 0.000 3000.000 0.000 20.000 100.000 0.000
# Comment 1: the previous line defines the maximum (1st data) and minimum (2nd)
# heating capacity, the maximum (3rd  data) and minimum (4th) cooling capacity,  the
# heating temperature setpoint (5th) and the cooling temperature setpoint (6th data).
# In this case set to 100. The last data is 0.
    0    2  18.000  # ctl type, law (free floating), start @
      0.  # No. of data items
    1  365  # valid Sat  1 Jan - Sun 31 Dec
     1  # No. of periods in day
    0    2   0.000  # ctl type, law (free floating), start @
      0.  # No. of data items
    1  365  # valid Sat  1 Jan - Sun 31 Dec
     1  # No. of periods in day
    0    2   0.000  # ctl type, law (free floating), start @
      0.  # No. of data items
# Function:Zone links
 1,0
```

* Mass Flow

no descrip # flow descr

1 # No. of controls

* Control mass

senses node (0)

-4 0 0 0 # sensor data

 # Comment 2: the previous line define the control sensor location for the flow
 # network

 # The first 3 data digits have specific meanings:

 # the first digit (-4) is the code to define that the sensor is related to a node in the
 # network.

 # the second digit (in this model 0) means at current zone. See the zone to which
 # this control is associated.

 # the third digit should be 0 (to remain undefined - no second node identified -
 # when sensing property differences)

 # the fourth digit is 0
 # NOTE: After changing your sensor location via the project manager and saving
 # your alterations, edit this NV.ctl file and make sure that the digits of the sensor
 # data are correct otherwise you will have to change them manually and save the
 # modifications.

actuates flow component: 3 win_open

-4 3 2 # actuator data

 # Comment 3: the previous line define the codes for the actuator location.

 # The 1st digit (-4) defines that the actuator is actuating on a flow component (ex 3rd
 # component - *win_open*)

 # the 2nd digit (for this particular model 3) defines the mass flow component number.
 # See the network component defined to find out the number of your actuating
 # component (your defined *win_open*).

 # The 3rd digit (for this particular model 2 namely *Z0_int* to *ext_south* and *Z0_int* to
 # *ext_north)* defines the number of connections related to your component 3
 # (*win_open).*

0 # No. day types

1 365 # valid Sat 1 Jan - Sun 31 Dec

3 # No. of periods in day

1 0 0.000 # ctl type (dry bulb > flow), law (on / off), start @

 # Comment 4: this particular model has been defined with a control law sensing the
 # temperature in the node and actuating the flow rate (defined in the network) -
index 1, with a on/off controller - 0

 # and starting at 0h.

2. # No. of data items

100.000 1.000

1 0 9.000 # ctl type (dry bulb > flow), law (on / off), start @

2. # No. of data items

25.000 1.000

1 0 18.000 # ctl type (dry bulb > flow), law (on / off), start @

2. # No. of data items

100.000 1.000

 # Comment 5: the controller will be ON (2nd digit 1 positive) when the temperature is # above 25°C (1st digit) between 9 and 18 hrs on week days.

1 365 # valid Sat 1 Jan - Sun 31 Dec

1 # No. of periods in day

1 0 0.000 # ctl type (dry bulb > flow), law (on / off), start @

2. # No. of data items

0.000 -1.000

1 365 # valid Sat 1 Jan - Sun 31 Dec

1 # No. of periods in day

1 0 0.000 # ctl type (dry bulb > flow), law (on / off), start @

2. # No. of data items

0.000 -1.000

 # and will be always OFF on saturday and sundays

Z0_int ext_south win_open Z0_int

Z0_int ext_north win_open Z0_int

#Make sure this last two lines are set correctly:

 # Z0_int connects to ext_south via win_open

 # Z0_int connects to ext_north via win_open